Hungry Horse Mitigation Program

Investigations of the Flathead River Native Species Project

Annual Report
2002

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Investigations of the Flathead River Native Species Project

Annual Progress Report
2002

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2002 Annual Progress Report

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Hybridization between Native Westslope Cutthroat Trout and Non-native Rainbow Trout in the Upper Flathead River System

The Flathead River system in northwest Montana is recognized as a regional stronghold for migratory (e.g., adfluvial and fluvial) westslope cutthroat trout (*Oncorhychus clarki lewisi*; WCT) throughout their historic range (Figure 1; Liknes and Graham 1988; Shepard et al. 1984). Migratory forms are important life-history strategies for maintaining genetic diversity and dispersal among populations (Rieman and McIntyre 1995), which is critical to the long-term persistence and preservation of a species (Allendorf and Leary 1988). Populations of migratory life-history forms, however, have declined due to genetic introgression (hybridization), habitat fragmentation, habitat degradation, and migration barriers such as dams, irrigation diversions and culverts (Liknes and Graham 1988; Behnke 1992). Consequently, WCT currently inhabit about 27.4% of their original range in Montana, and genetically pure populations occupy only 2.5% of their historic range (Liknes and Graham 1988). In response to population declines, Montana Fish, Wildlife & Parks (MFWP) and the American Fisheries Society (AFS) classified WCT as a species of special concern and the U.S. Forest Service classified them as a sensitive species. Currently, WCT are petitioned for listing as a threatened species under the Endangered Species Act.

Hybridization between native WCT and non-native rainbow trout (*O. mykiss*; RBT) is a leading factor contributing to the decline of genetically pure cutthroat trout populations in the upper Flathead River system. In 1998, we initiated a study to examine spatial and temporal patterns of hybridization between native WCT and non-native RBT in streams of the upper Flathead River system (Hitt 2002; Hitt et al. 2003-*In review*). We detected hybridization at 24 of 42 (57%) sites sampled from 1998 to 2001. New *O. mykiss* introgression was documented in 8 of 11 (73%) sites that were determined to be non-hybridized in 1988. The spatial distribution of hybrid populations (e.g., patterns of spatial autocorrelation) and patterns of genetic inheritance (e.g., and linkage disequilibrium) indicated that hybridization is spreading among sites and is advancing primarily by post-F_1 hybrids. Although hybridized sites were distributed widely throughout the study area, the amount of admixture from *O. mykiss* decreased with increasing upstream distance from the Flathead River mainstem, suggesting that *O. mykiss* introgression is spreading in an upstream direction. Recent radiotelemetry studies (Muhlfeld et al. 2000; Muhlfeld et al. 2001) have also documented movements of hybrid (WCT x RBT) spawners into North Fork tributaries historically inhabited by WCT.

Little information exists regarding the demographics of WCT x RBT hybrid populations in the upper Flathead River drainage. Recent concern has arisen that genetically pure WCT populations are at high risk of further declines primarily due to hybridization with non-native RBT. The specific distribution, population structure, abundance, and seasonal movements of hybrid trout populations are largely unknown. These unknown life-history preferences warrant immediate research and mitigation to protect the remaining endemic WCT for further population declines in the Flathead River system.
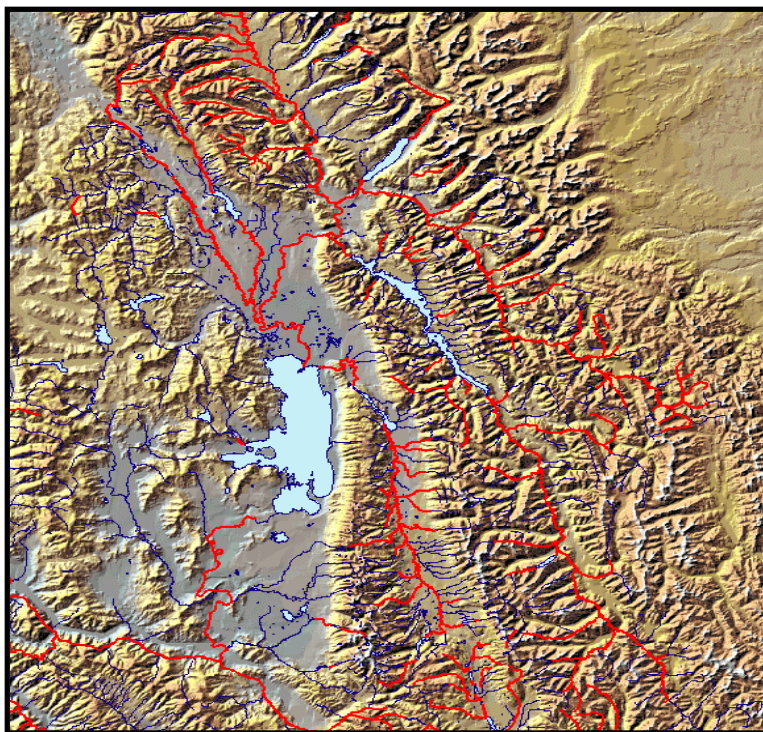
FIGURE 1. The distribution of westslope cutthroat trout (shown in red) in the upper Flathead River system, Montana.
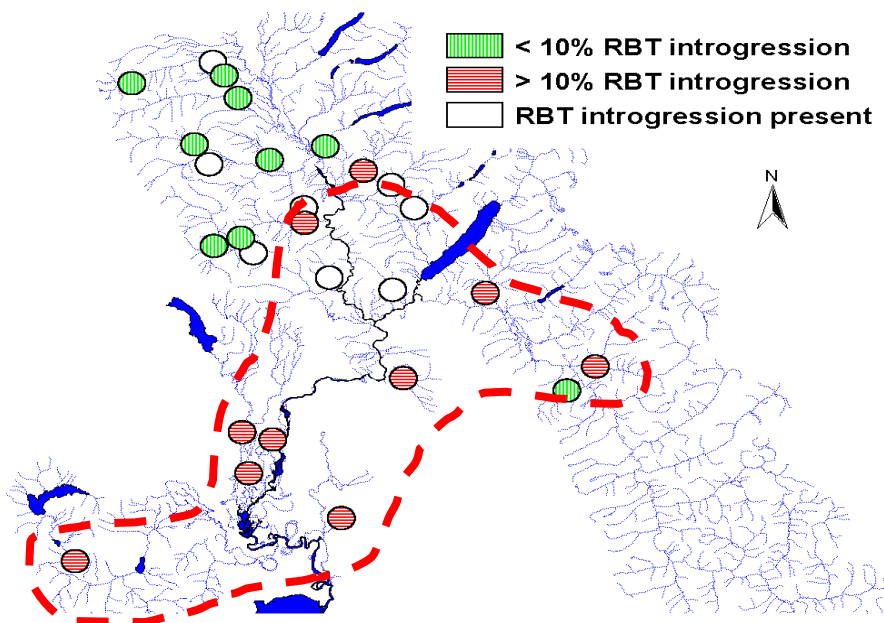
FIGURE 2. The current distribution of westslope cutthroat trout based on results of a recent basin-wide genetics survey (Hitt 2002) in the upper Flathead River system, Montana.

The 2002 objectives for restoration and protection of westslope cutthroat trout are:

1. To examine spatial patterns of hybridization between westslope cutthroat trout and rainbow trout in the upper Flathead River system, Montana;

2. To quantify summer distribution, abundance, size-class structure, and genetic composition of known hybrid populations in the upper Flathead River system;

3. To assess movements and spawning locations of adult rainbow and hybrid trout in the upper Flathead River system;

4. To assess the population abundance of spawning rainbow and hybrid trout in Abbot Creek and initiate a suppression program to prevent rainbow and hybrid spawners from ascending the stream; and

5. To monitor population dynamics of trout populations inhabiting the main stem Flathead River during winter.

*Hybridization between westslope cutthroat trout and rainbow trout
in the upper Flathead River system, Montana: a summary report by Hitt et al. (In
review)*

Hybridization is perhaps the primary threat facing westslope cutthroat trout (Allendorf
and Leary 1988). Introductions of non-native rainbow trout and Yellowstone cutthroat
trout *O. c. bouvieri* commonly result in the production of hybrid swarms and the probable
loss of local adaptations in native populations (Allendorf et al. 2001). However, the
distribution of hybridized populations and the factors associated with the spread of
hybridization remain poorly understood. In this study, we examined spatial and temporal
patterns of hybridization between westslope cutthroat trout and rainbow trout in the upper
Flathead River system, Montana. Our objectives were to map the distribution of rainbow
trout introgression in the study area and assess spatial and temporal patterns of
hybridization.

Methods

For this survey, 42 stream sites were sampled between 1998 and 2001 within the upper
Flathead River system. In 41 of 42 sites, single-pass electrofishing was conducted to
capture *O. spp*. individuals within sample reaches (> 300 m). Site 42 (Whitefish River)
was sampled by electrofishing from a drift boat. Captured fish were anesthetized and a
small portion of the anal fin was excised and stored in 95% ethanol for laboratory
analyses.

Paired Interspersed Nuclear Element Polymerase Chain Reaction (PINE-PCR) techniques
were used to assess the hybridization status of each sample population (Spruell et al.
2001; Kanda et al. 2002). The genetic data were screened for probable westslope
cutthroat trout polymorphisms and linkage disequilibrium. Genetic analyses were
conducted by the Wild Trout and Salmon Genetics Laboratory (University of Montana).

Temporal trends were assessed against allozyme data from Huston (1988) within 13
North Fork tributary sites. Although allozymes are codominant fragments and PINE-
PCR techniques utilize dominant nDNA fragments, these two types of analyses have
shown concordance in hybrid detection at the population level (Spruell et al. 2001). See
Hitt (2002) for calculations and further details.

Results

Of the 42 sample populations, 24 (57%) showed rainbow trout introgression (Figure 1;
Tables 1 & 2). Of the 24 hybridized populations, three showed statistically significant
patterns of linkage disequilibrium. Within the 21 hybridized populations that lacked
significant linkage disequilibrium, the percent genetic contribution of rainbow trout
(GC_r) ranged from 0.9% to 98.2% (Figure 2; Table 2). Most hybridized populations
(14/21) contained less than a 10% genetic contribution from rainbow trout. Within in the
North and Middle Fork basins, all populations with greater than 10% introgression were

located within a 25 km zone above the confluence of the North and Middle Forks. Mainstem tributary sites (sites 40, 41, 42) showed GC_r values in excess of 89% (Figure 2; Table 2).

Although hybridized populations were distributed widely throughout the study area, the magnitude of rainbow trout introgression decreased with increasing upstream distance from the Flathead River main-stem, suggesting that introgression is spreading in an upstream direction. North Fork and Middle Fork sites showed similar distance effects with main-stem sites and excluding main-stem sites (Analysis of Covariance interaction terms $P > 0.45$). Although the main-stem sites (sites 40, 41, 42) were influential sites, their absence did not change the general pattern of decreasing rainbow trout introgression with increasing distance from Flathead Lake in either the North Fork or Middle Fork basins.

Rainbow trout introgression has spread within the upper Flathead River system since the mid-1980s. We detected new introgression in 7 of 11 sites determined to be non-hybridized westslope cutthroat trout by Huston (1988). In contrast, we detected non-hybridized westslope cutthroat trout in upper Moose Creek (site 1) where Huston (1988) reported low levels of introgression. Huston (1988) attributed the rainbow trout introgression in Moose Creek to accidental introductions of hybridized broodstock in the headwater lake above this creek. Langford Creek (site 28) showed hybridization in both surveys, but we could not calculate a percent introgression for this population due to the presence of linkage disequilibrium.

Discussion

Our findings indicate that (a) rainbow trout introgression is rapidly invading westslope cutthroat trout populations in the study area and that (b) hybridization is spreading in an upstream direction from the Flathead River main-stem.

These findings are consistent with a recent study of hybrid trout migrations in the Flathead River system. In 2002, radio telemetry surveys documented upstream spawning migrations by westslope x rainbow trout hybrids from the Flathead River main-stem to Dutch Creek (near site 22), Hay Creek (near site 9), and Lincoln Creek (near site 33) (C. Muhlfeld, MFWP, unpublished data). In this survey, we detected hybridized populations in each of these streams. These findings are also consistent with a recent survey of westslope x rainbow trout hybridization in the Kootenay River system (Rubidge et al. 2001).

This study contributes new insight for the determination of westslope cutthroat trout status in the upper Flathead River system and throughout their native range. Moreover, these data will be useful to prioritize suppression efforts currently underway by Hungry Horse Mitigation (Muhlfeld et al. 2002; Muhlfeld et al. 2003). See Hitt (2002) and Hitt et al. (*In review*) for a full presentation of this study.

TABLE 1. Non-hybridized westslope cutthroat trout sites detected in the study area. See Hitt (2002) for calculations.

Site code	Region	Site name	WCT poly[1]	P (1%)[2]	P (2%)[3]
1	North Fork	Moose Creek, upper		89.9	99.0
2		Moose Creek, lower	*	95.1	99.8
6		Akokala Creek	*	95.1	99.8
7		Bowman Creek		95.1	99.8
8		Hay Creek, upper	*	94.5	99.7
10		Moran Creek		92.1	99.4
11		Quartz Creek, upper		94.5	99.7
12		Quartz Creek, lower	*	91.0	99.2
15		Deadhorse Creek		93.8	99.6
16		Cyclone Creek, upper		94.5	99.7
18		Logging Creek, upper		85.5	97.9
23		Big Creek, upper		95.1	99.8
27		Kletomas Creek	*	95.1	99.8
30		Depuy Creek		95.1	99.8
36	Middle Fork	Tunnel Creek		95.1	99.8
37		Park Creek		93.0	99.5
38		Ole Creek		80.0	99.2
40		Bear Creek	*	79.2	95.7

[1]Stars indicate sites that showed PINE fragments normally diagnostic for RBT but assumed to be WCT polymorphisms.
[2]Probability of detecting as little as 1% RBT introgression.
[3]Probability of detecting as little as 2% RBT introgression.

TABLE 2. Hybridized sites detected in the study area. Percent genetic contributions of rainbow trout (GC_r), westslope cutthroat trout (GC_w), and Yellowstone cutthroat trout (GC_y) are presented. See Hitt (2002) for calculations.

Site code	Site name	LD index[a]	GC_r[b]	GC_w[b]	GC_y
3	Red Meadow Creek, upper	0.992	1.4	98.6	0
4	Red Meadow Creek, lower	0.064	*	*	0
5	South Fork Red Meadow Creek	0.996	.9	99.1	0
9	Hay Creek, lower	0.994	1.1	98.9	0
13	Coal Creek (I)	0.834	3.6	96.4	0
14	South Fork Coal Creek	0.541	6.1	93.9	0
17	Cyclone Creek, lower	0.457	7.4	92.6	0
19	Logging Creek, lower	0.800	2.1	97.9	0
20	Anaconda Creek	0.474	27.4	72.6	0
21	Camas Creek	0.221	24.5	75.5	0
22	Dutch Creek	0.157	*	*	0
24	Big Creek, middle	0.939	1.4	98.6	0
25	Nicola Creek	0.712	4.0	96.0	0
26	Skookoleel Creek	0.554	1.7	98.3	0
28	Langford Creek	0.217	*	*	0
29	Big Creek, lower	0.800	24.2	75.8	0
31	McGinnis Creek	0.594	9.8	90.2	0
32	Rubideau Creek	0.092	11.1	88.9	0
33	Lincoln Creek	0.207	18.5	81.5	0
34	Coal Creek (II)	0.840	5.3	94.7	0
35	Stanton Creek	0.987	2.3	97.7	0
39	Essex Creek	0.925	1.4	95.2	3.5
41	Abbot Creek	na	97.5	2.5	0
42	Mill Creek	na	89.4	10.6	0
43	Whitefish River	na	98.2	1.8	0

[a]Linkage Disequilibrium Index: average linkage disequilibrium P values determined from Fisher's exact test of all pair-wise comparisons for diagnostic RBT fragment frequencies. Linkage disequilibrium was not calculated for populations with $GC_r > 0.50$.
[b]Stars indicate sites that showed statistically significant patterns of linkage disequilibrium within at least one pair-wise comparison. Because PINEs are dominant markers, percent contribution could not be calculated under the assumption of Hardy-Weinberg conditions.
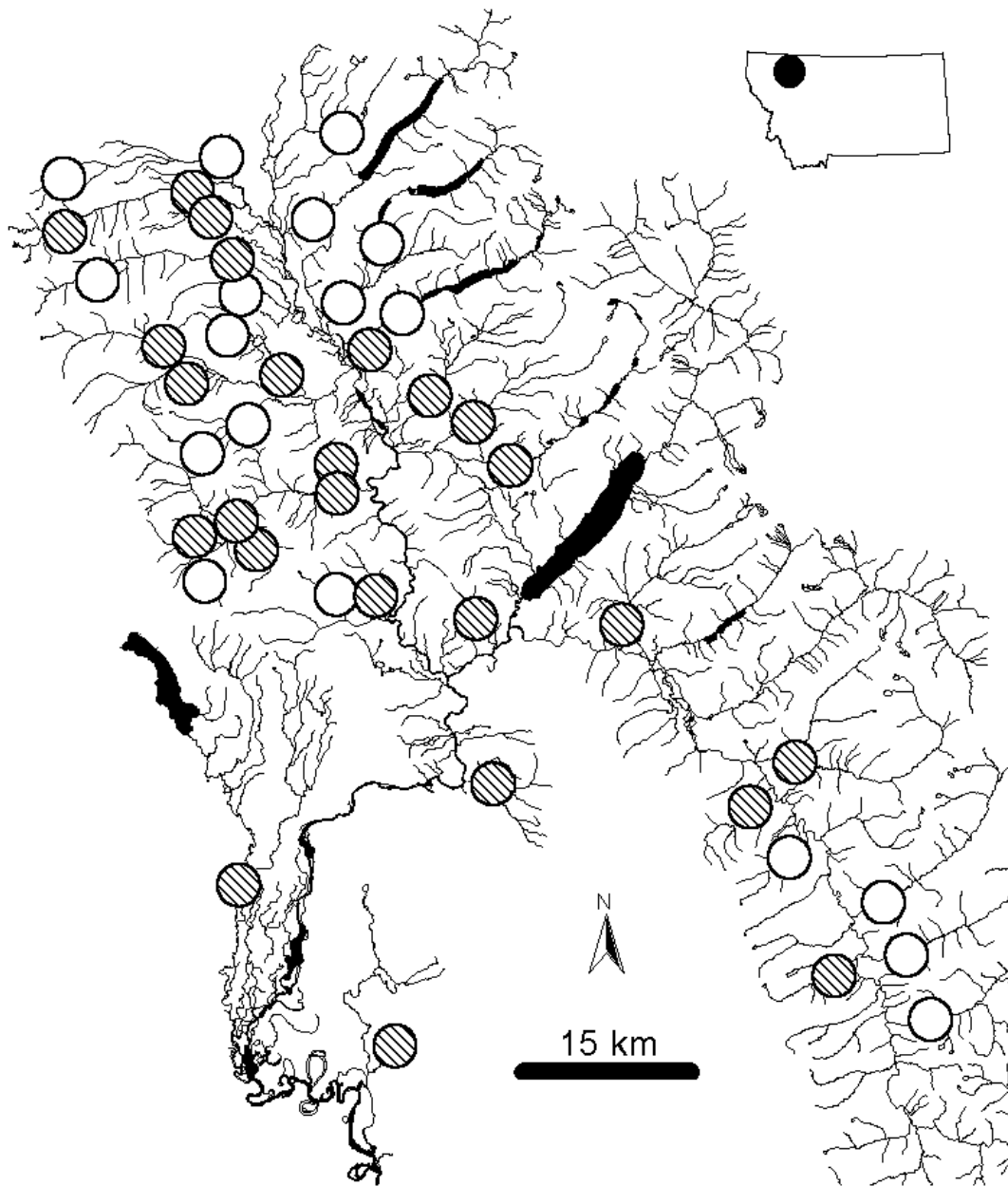
FIGURE 1. The distribution of westslope cutthroat trout sample populations (open circles) and hybridized sample populations (hatch-marked circles) in the study area.
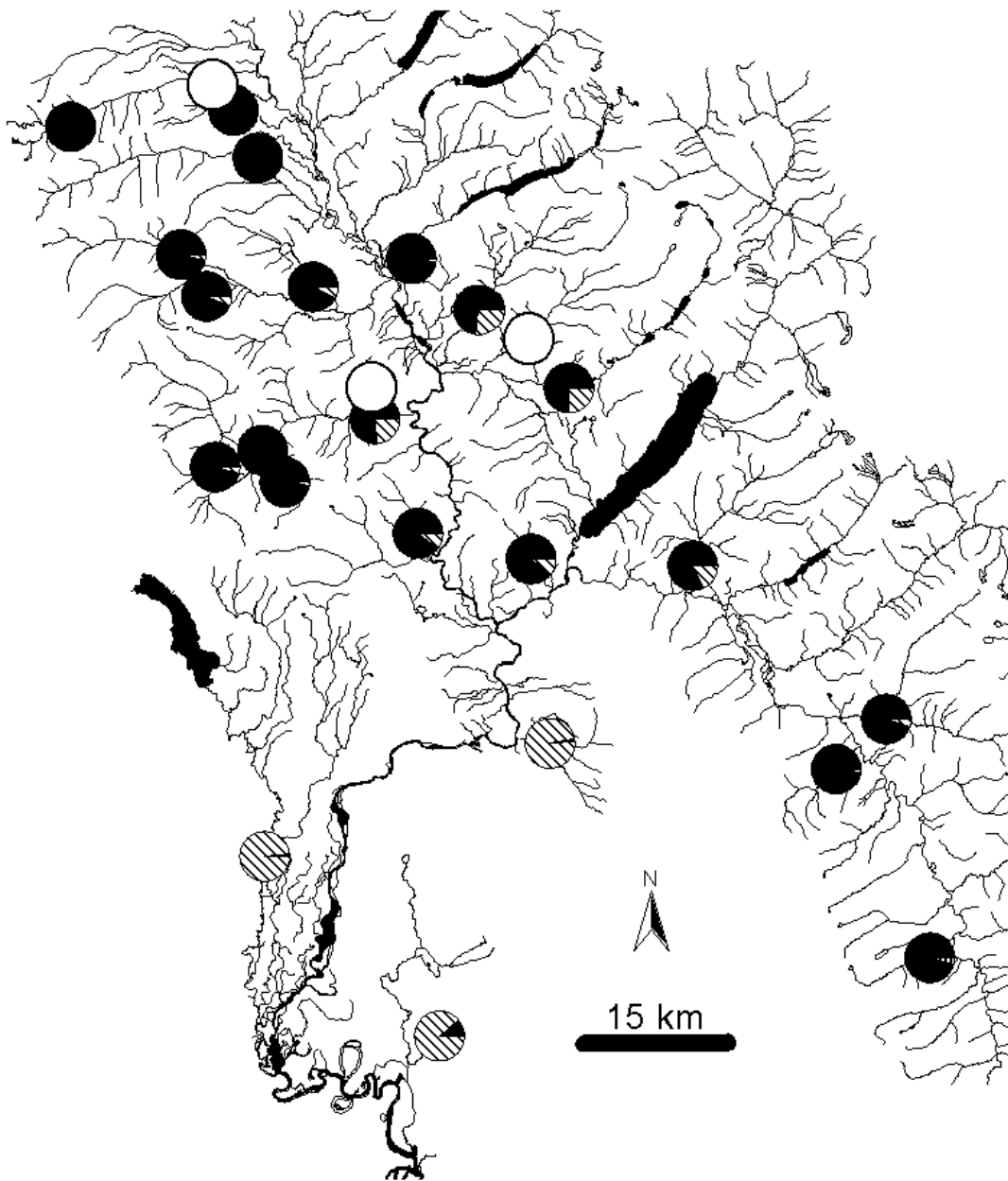
FIGURE 2. Relative contributions of rainbow trout, westslope cutthroat trout, and Yellowstone cutthroat trout in hybridized sample populations. In each pie chart, the black area corresponds to the percent westslope cutthroat trout contribution and diagonal hatched area corresponds to the percent rainbow trout contribution. In Essex Creek (site 39), the Yellowstone cutthroat trout contribution is indicated with vertical hatch marks.

Hybrid Population Surveys

We conducted population surveys in streams of the upper Flathead River drainage during the summer and fall of 2002. Surveys were conducted to estimate abundance, age class structure, and genetic makeup of these expanding populations. Information gained from this study will be used to prioritize and evaluate WCT x RBT suppression efforts implemented by Hungry Horse Mitigation.

Methods

Multiple pass depletion estimates (Ricker 1975) were completed on Abbot Creek on the main-stem Flathead, Dutch and Anaconda Creeks in the North Fork, and Lincoln Creek in the Middle Fork of the Flathead River. Sections were 150 m in length, with the exception of Abbot Creek that included two 75 m sections. A habitat break was selected to begin the upper boundary and a block net was placed across the channel at the lower boundary. At least 10 stream width measurements were taken throughout the section to estimate the sampling area. Multiple passes were conducted with one or two backpack electrofishers (Smith-Root Model 15 – D) moving in an upstream to downstream direction. All fish from each pass were netted and placed in a live car. We identified and measured the total length of fish greater than 75 mm and enumerated fish less than 75 mm. Fin clips were taken from a random sample of fish for a genetic molecular analysis. Water temperature and GPS coordinates were also recorded.

We completed base-line population surveys in two unnamed tributaries to the North Fork Flathead River upstream of Blankenship Bridge. These streams were surveyed to estimate species composition and degree of introgression. Surveys were conducted with backpack electrofishing equipment from the mouths to the first fish barrier identified upstream. Fish were identified, measured and sampled for genetics. Water temperature and GPS coordinates were also recorded. Since WCT are the native species in the Flathead drainage and the focus of these surveys, population estimates were not completed for brook trout (*Salvelinus fontinalis*; EBT).
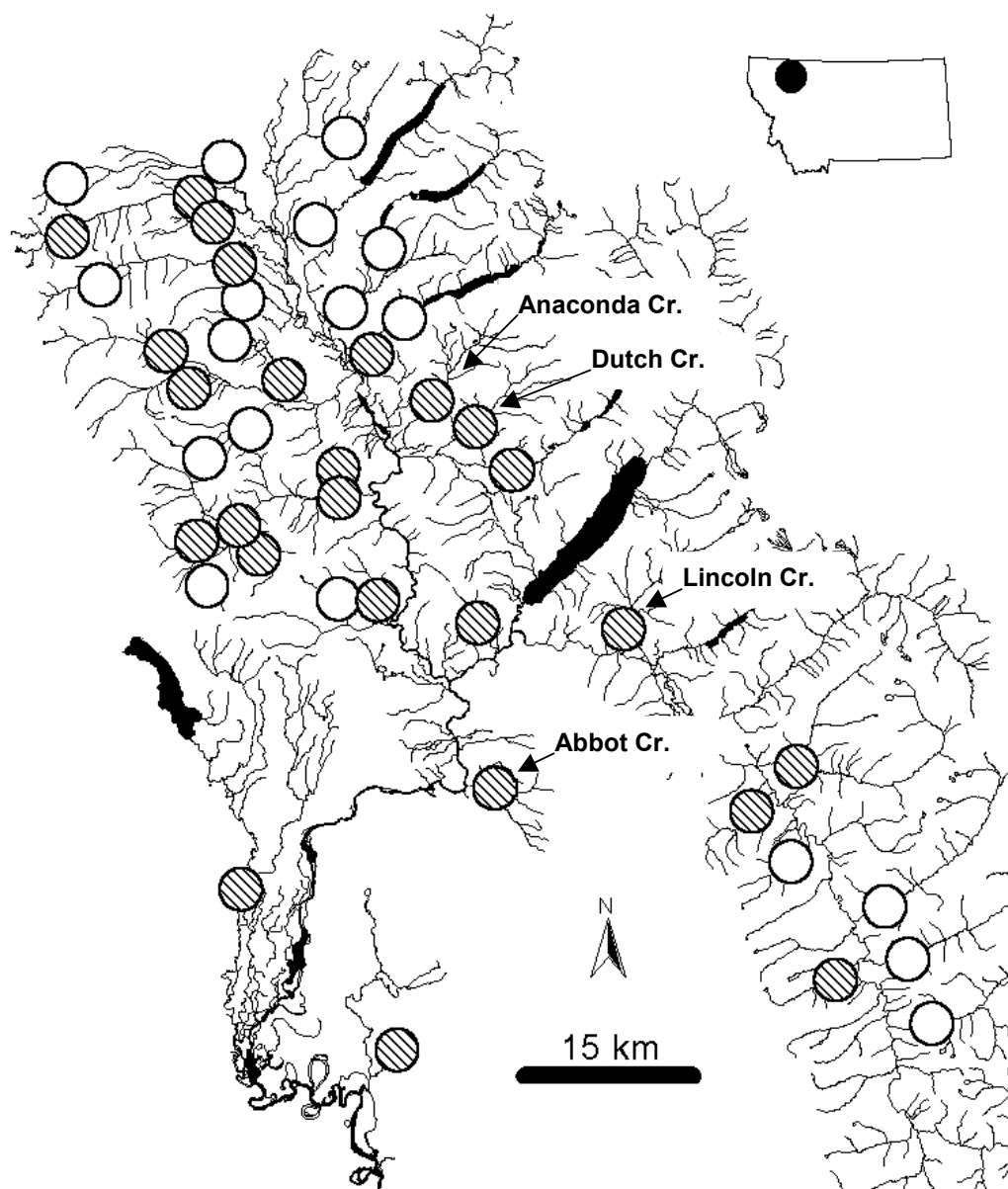
FIGURE 1. Study streams and the distribution of WCT (open circles) and admixed populations of WCT x RBT (hatch-marked circles) in the study area.

Results and Discussion

Anaconda Creek

Anaconda Creek originates on the west slope of the Livingston Mountain Range in Glacier National Park (Figure 1). Hitt (2002) reported that the *Oncorhynchus spp.* fish population inhabiting Anaconda Creek contained 27.4% RBT genes (Table 1). This stream had the highest percentage of introgression by RBT of all drainages sampled in the North Fork (Hitt 2002) and, thus, has been identified as a major source of hybridization in the upper river system.

A population estimate was obtained on 2 October 2002, by a three-pass application of the removal method using backpack electrofishing equipment. The survey section was located downstream of the Inside North Fork Road crossing in Glacier National Park. A 150 m section was chosen that had an average width of 5.2 m, a wetted area of 780 m^2, and a water temperature of 8^oC at the time of sampling.

We captured at total of 64 fish greater than 75 mm (TL) and seven fish less than 75 mm (Figure 2). The mean length of fish captured was 116 mm (SD = 32; range, 51 – 235 mm). Examination of the length frequency revealed that age-0 and age-1 fish dominated the size composition of the population, with a few older fish present in the sample (Figure 2). The population estimate was 66 fish >75mm (SE = 2.3; lower 95% Confidence Interval = 64, upper CI=71).

TABLE 1. Admixed sites detected in the study area. Percent genetic contributions of rainbow trout (GC_r), westslope cutthroat trout (GC_w), and Yellowstone cutthroat trout (GC_y) are presented.

Site name	GC_r[1]	GC_w[1]	GC_y	Estimate[2]
North Fork				
Anaconda Creek	27.4	72.6	0	66
Dutch Creek	*	*	0	24
Middle Fork				
Lincoln Creek	18.5	81.5	0	11
Main-stem				
Abbot Creek	97.5	2.5	0	+

[1]Stars indicate sites that showed statistically significant patterns of linkage disequilibrium within at least one pair-wise comparison. Because PINEs are dominant markers, percent contribution could not be calculated under the assumption of Hardy-Weinberg conditions.
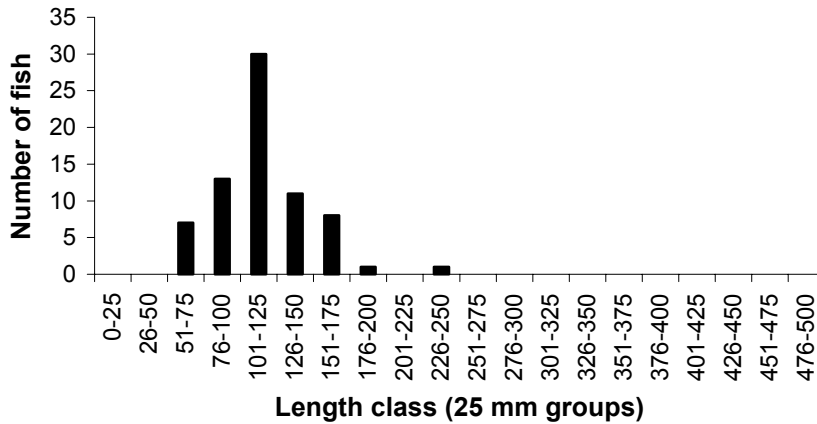[2]See Table 2 for Abbot Creek population estimates.

FIGURE 2. Length frequency distribution (*N* = 64) for *Onc. spp.* sampled in Anaconda Creek on 2 October 2002.

Dutch Creek

Dutch Creek, a tributary to Camas Creek in the North Fork Flathead River, originates on the west slope of the Livingston Mountain Range and is located entirely within Glacier National Park (Figure 1). A 23 fish genetic sample taken from Dutch Creek in 1998 showed the occurrence of F-1 hybrids present in the population (Muhlfeld et al. 2001; Hitt 2002). Further, two radio-tagged hybrids spawned in the Camas/Dutch Creek drainage during the spring of 2001 (Muhlfeld et al. 2002). These data suggest a recent upward expansion of RBT in the Flathead system, and that the Dutch/Camas Creek complex is a major source of hybridization in the North Fork Flathead River that may necessitate further suppression efforts.

A population estimate was obtained on 28 August 2002, by a two-pass application of the removal method using backpack electrofishing equipment. The survey section was located downstream of the Inside North Fork Road crossing in Glacier National Park. A 150 m section was chosen that had an average width of 4.7 m, a wetted area of 706 m^2, and a water temperature of 14.5^{o}C at the time of sampling.

We captured a total of 23 fish greater than 75 mm and 1 fish less than 75 mm (Figure 3). All captured fish appeared to be *O spp*. The mean length of fish captured was 109 mm (SD = 22; range, 75 – 167 mm). The length frequency distribution showed predominantly age-1 fish in the sample (Figure 3). The population estimate for this stream was 24 (SE = 2.2; lower 95% CI = 23, upper 95% CI = 29). Twenty-two tissue samples were collected from individual fish for later molecular genetic analyses.
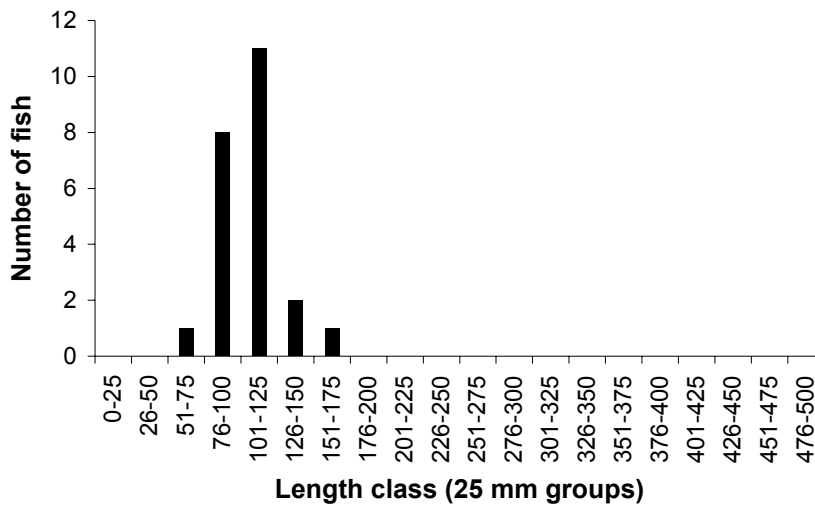
FIGURE 3. Length frequency distribution ($N = 23$) for *Onc. spp.* sampled in Dutch Creek on 28 August 2002.

Lincoln Creek

Lincoln Creek, a tributary to the Middle Fork of the Flathead River, originates on the west slopes of Glacier National Park near West Glacier. A 22 fish genetic sample taken from Lincoln Creek in 1998 contained 18.5% RBT introgression (Muhlfeld et al. 2001; Hitt 2002), indicating that the stream is a major source of hybridization in the Middle Fork Flathead River drainage.

A population estimate was obtained on 26 September 2002, by a two-pass application of the removal method using backpack electrofishing equipment. The survey section was located approximately 4 km upstream of the confluence with the Middle Fork Flathead River in Glacier National Park. A 150 m section was chosen that had an average width of 7.7 m, a wetted area of 1,155 m^2, and a water temperature of 10°C at the time of sampling.

The fish population was composed of *O. spp.* and EBT. Total number of captured *O. spp.* was 21 fish greater than 75 mm, and 10 fish less than 75 mm (Figure 4). The mean length of captured *O. spp.* was 97 mm (SD = 50; range, 50 – 259 mm). The length frequency distribution showed predominantly age-0 and age-1 fish represented in the sample (Figure 4), with one older fish (TL = 259 mm). The population estimate for *O. spp.* was 11 fish greater than 75 mm (SE = 0.3; lower 95% CI = 10, upper 95% CI = 12). A genetic sample was taken from all captured *O. spp.* ($N = 21$). Total number of captured EBT was 11 fish greater than 75 mm, and two fish less than 75 mm. Mean length of the captured EBT was 117 mm (SD = 48; range, 64 – 210 mm).

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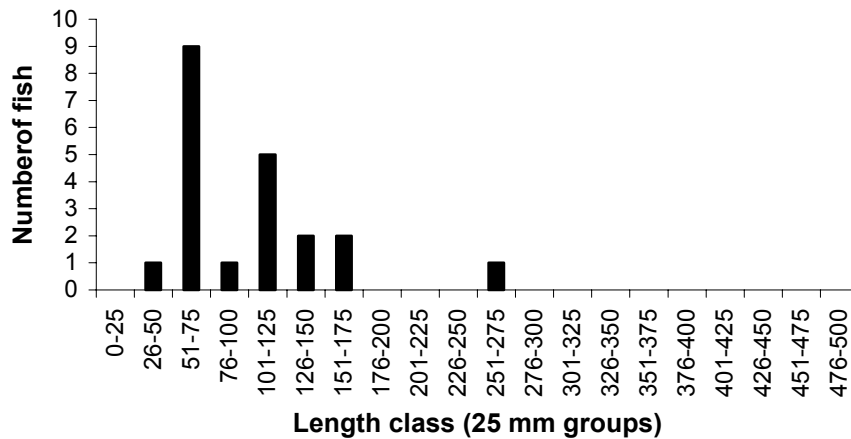
FIGURE 4. Length frequency distribution (*N* = 21) for *O. spp.* sampled in Lincoln Creek on 26 September 2002.

Unnamed North Fork Tributary 1, "Steamer Creek"

This stream is an un-named tributary to the North Fork Flathead River located approximately 3.1 km above the North Fork's confluence with the Middle Fork (Lat. = 48° 28.990 N, Long. = 114° 05.715 W). This small drainage enters the North Fork from the east side and is within the boundaries of Glacier National Park. It was named Steamer Creek by our crew because of the large piles of fresh grizzly bear scat found along its banks.

Steamer Creek was sampled to obtain baseline data on fish populations in this stream, and also because several WCT x RBT adult spawners were consistently relocated near the mouth during the spawning period. We completed a one-pass backpack electrofishing survey from the mouth to approximately 150 m upstream to the first series of shallow beaver ponds on 27 August 2002. The drainage upstream of the beaver ponds was classified as unsuitable fish habitat and, therefore, was not sampled.

A total of five *O. spp.*, were captured in the stream (mean length = 113 mm; SD = 12; range, 102 – 129 mm). In addition, several sculpins *Cottis spp.* and tailed frogs *Ascaphus truei* were collected during the survey. Genetic samples were taken from all five trout to check for species identification and presence of hybridization. The water temperature was 7°C at the time of sampling.

Unnamed North Fork Tributary 2, "Third Creek"

Third Creek is another un-named creek that enters the North Fork of Flathead River from the east side within Glacier National Park. It is located about 4.3 km above the North Fork's confluence with the Middle Fork (Lat. = 48° 29.368 N, Long. = 114° 06.491 W).

We conducted a fisheries survey in Third Creek to obtain baseline fish population data, and because several WCT x RBT adult spawners were consistently relocated near the mouth during the spawning period (Muhlfeld et al. 2002; Muhlfeld et al. 2003).

The survey included a one-pass application of the removal method using backpack electrofishing equipment on 27 August 2002. The stream was sampled up to the base of a large beaver dam/pond complex. The drainage beyond this point was not sampled. A total of 58 *O. spp.* were captured; of these 31 fish were measured and 27 were recorded as age-0 fish and simply counted. Average total length for the measured fish was 45 mm (SD = 20; range, 25 – 116mm). One EBT (TL = 116 mm) and 8 tailed frogs were also captured. Genetic samples were taken from 30 of the *O spp.* The water temperature was 7.5°C during the time of sampling.

Abbot Creek

In order to quantify the success of our trapping and suppression efforts (see below), we conducted population estimates in 2001 and 2002. Two spawning and rearing areas (an upper and lower site) were sampled on 1 and 9 October in 2001, and 23 August in 2002.

*2001.─*A population estimate was obtained on 1 October 2002, by a three-pass application of the removal method using backpack electrofishing equipment in the lower section. The lower electrofishing section was located approximately 200 m upstream of the mouth at the Flathead River. The 75 m section had an average width of 2.8 m, a wetted area of 210 m², and a water temperature of 7.5°C at the time of sampling. The fish population was composed of *O. spp.* (n = 46; 75%) and EBT (n = 15; 25%). Most of the *O. spp.* were age-0 fish, with a few age-1 fish present in the sample (Figure 5). Mean total length of the captured EBT was 119 mm (SD = 19; range, 87 – 147 mm). The population estimate for RBT in this section was 79 fish (SE = 44; lower 95% CI = 41, upper 95% CI = 167).

A population estimate was obtained on 9 October 2002, by a three-pass application of the removal method using backpack electrofishing equipment in the upper section of Abbot Creek. The sample reach was located on private property approximately 350 m upstream of Highway 2 in a low-gradient reach. The 75 m section had an average width of 2.7 m, a wetted area of 202 m², and a water temperature of 11°C at the time of sampling. Game fish populations were composed of *O. spp.* (n = 92; 48%) and EBT (n = 98; 52%). Numerous sculpins were also captured. The captured *O. spp.* were predominately age-0 fish, with a few age-1 fish present in the sample (Figure 5). The population estimate for RBT in this section was 84 fish (SE = 1.1; lower 95% CI = 84, upper 95% CI = 86).
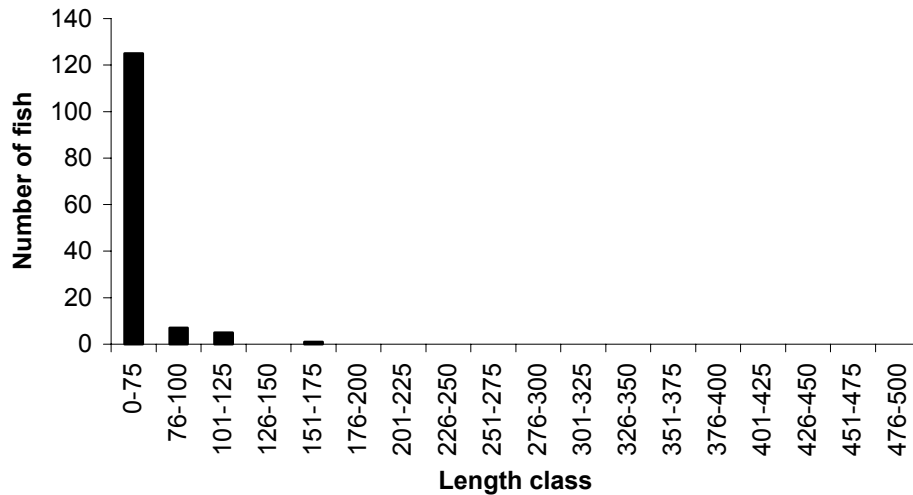
Figure 5. Combined length frequency distribution (*N* = 138) for sites 1 and 2 in Abbot Creek in 2001.

2002.– The lower and upper sampling sites were replicated from 2001 locations. A population estimate was obtained on 23 August 2002, by a three-pass application of the removal method using backpack electrofishing equipment in the lower section of Abbot Creek. The average stream width was 3.5 m, wetted area was 262 m^2, and the water temperature was 12°C at the time of sampling. Game fish included *O. spp* (n= 102, 77%), EBT (n = 31, 23%), mountain whitefish (*Prosopium williamsoni*; n=8) and longnose suckers (*Catostomus catostomus*; n=3). Of all trout sampled, 90% were less than 75 mm in total length and represented the age-0 group (Figure 6). The population estimate for *O. spp* in this section was 104 fish (SE = 4.1; lower 95% CI = 98, upper 95% CI = 112).

A population estimate was obtained on 23 August 2002, by a three-pass application of the removal method using backpack electrofishing equipment in the upper section of Abbot Creek. The average stream width was 2.7 m, wetted area was 202 m^2, and the water temperature was 16°C at the time of sampling. The fish population was comprised of *O. spp.* (n = 90, 65%), EBT (n = 49, 35%) and sculpins. Of all trout sampled, 83% were less than 75 mm in total length. Of the 4 *O. spp.* measured, the average total length was 111 mm (SD = 27; range, 78 – 144 mm). The majority of fish were age-0, with a few age-1 fish (Figure 6). The average total length of EBT greater than 75 mm was 128 mm (SD = 34; range, 100 – 228 mm). The population estimate for *O. spp.* in this section was 99 fish (SE = 7.3; lower 95% CI = 87, upper 95% CI = 113).
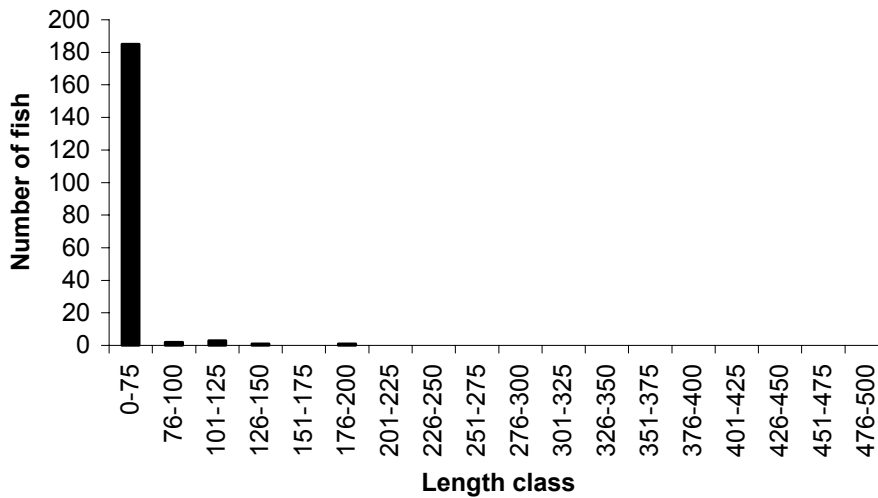
FIGURE 6. Combined length frequency distribution (*N* = 192) for sites 1 and 2 in Abbot Creek in 2002.

The only estimates completed prior to 2001 on this stream were conducted on EBT. Species composition surveys were completed in the summer of 1993 and 1994 and spring of 1996 and 1998. Various locations and section lengths within the Abbot drainage were used. EBT, RBT, sculpins and WCT were noted. The catch was predominantly EBT, followed by sculpins and RBT; few WCT were recorded. Total length for RBT ranged from 30 to 226 mm, with most fish representing the age-0 and age-1 year classes.

Population estimates for both sites on Abbot Creek should be continued to monitor the effectiveness of the RBT suppression program. In the future, we expect the abundance of RBT in Abbot Creek to decrease as spawning RBT are successfully removed. A reduction in numbers may take several years of trapping to substantially impact RBT numbers in Abbot Creek.

TABLE 2. Summary of population estimates for *Onc. spp.* (< 75 mm) sampled in Abbot Creek (upper and lower sites) in 2001 and 2002.

| | 2001 | | 2002 | |
Statistic	Lower	Upper	Lower	Upper
Total number of fish	46	92	102	90
Number of fish < 75 mm	41	84	98	87
Mean length (mm)	122	95	121	111
SD	28	5	44	27
Range	(106 – 172)	(88 – 105)	(76 – 180)	(78 – 144)
Population Estimate	79	84	104	99
SE	44	1.1	4.1	7.3
Upper 95% C.I.	41	84	98	87
Lower 95% C.I.	167	86	112	113

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Abbot Creek Non-native Trout Suppression

Recent genetic surveys revealed that Abbot Creek, a tributary to the Flathead River near Martin City, supports a WCT x RBT hybrid population. Further, radio-telemetry studies (Muhlfeld et al. 2000; Muhlfeld et al. 2001; Muhlfeld et al. 2002) found that that a majority of hybrid fish tracked during the spawning period migrate to Abbot Creek and spawn in the stream. Combined, this information suggests that Abbott Creek is a major source of hybridization in the upper Flathead River system and thus poses a threat to the long-term persistence of migratory cutthroat trout populations in the Flathead system.

As a result of these findings, an upstream spawning trap was operated at the mouth of Abbot Creek from 2000 to 2002 to remove rainbow and hybrid trout spawners attempting to ascend the stream. In 2001, fish were released back downstream of the trap. In 2002, the decision was made to remove all captured RBT spawners. Non-native and hybrid trout suppression in Abbot Creek was initiated as part of a larger effort to reduce or eliminate source hybrid populations located in valley bottom streams of the upper Flathead River system. Eradication of source hybrid populations will slow or stop the spread of hybridization and reduce the pioneering of new spawning areas by RBT that has been documented elsewhere in the upper river system (Hitt 2002; Hitt et al.- *In review*). All RBT and hybrids captured in the Abbot Creek trap in 2002 were removed and transported to closed basin ponds within Kalispell to provide urban fishing opportunities for local children.

We captured 188 *O. spp.* and 2 WCT in Abbot Creek from 1-28 May 2002. The average length of RBT was 358 mm (range, 83-505 mm). Total number of ripe spawners identified was 79 males and 71 females. Mean daily temperature ranged from 4.0 to 7.0^{o}C, and discharge ranged from 305.6 to 1171.6 cms. The trap was run continuously from 28 March 2002 to 29 May 2002, for a total of 63 days (Table 3). RBT began entering Abbot Creek as both temperature and discharge increased during the rising limb of the hydrograph (Figures 7 and 8).

TABLE 3. Abbot Creek trap summaries for 2000, 2001, and 2002.

	2000	2001	2002
# RBT captured	77	140	74(114*)
# WCT captured	3	0	2
Mean total length (mm)	357	362	358
Total length range (mm)	138 - 549	71 - 540	83 - 505
# Ripe males	40	33	79
# Ripe females	35	27	71
Trap dates	31 March- 2 June	2 April – 8 June	28 March – 20 May
# Trap days	64	68	54
CPUE	1.2	2.1	1.4
Run length	3 April – 2 June	17 April – 6 June	1 May – 28 May
Mean run date	3 May	12 May	14 May
Discharge range (cms)	156.2 – 931.1	99.1 – 687.7	305.6 – 1171.6
Mean discharge (cms)	491.8	331.0	608.0
Temperature range (^{o}C)	1.5 – 8.5	4.5 – 11.0	4.0 – 7.0
Mean temperature (^{o}C)	6.1	7.3	5.4

* Fish captured by electrofishing.
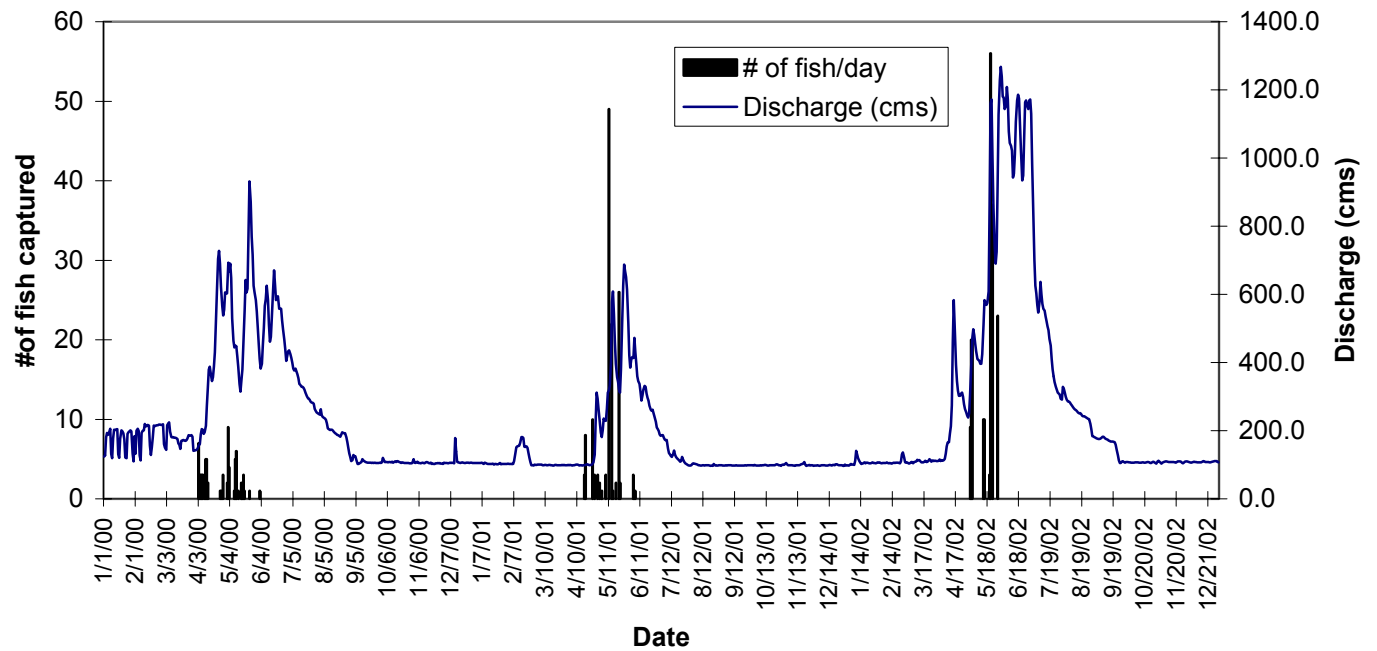
FIGURE 7. Number of fish captured at the Abbot Creek trap as related to the Flathead River hydrograph in 2000, 2001, and 2002.
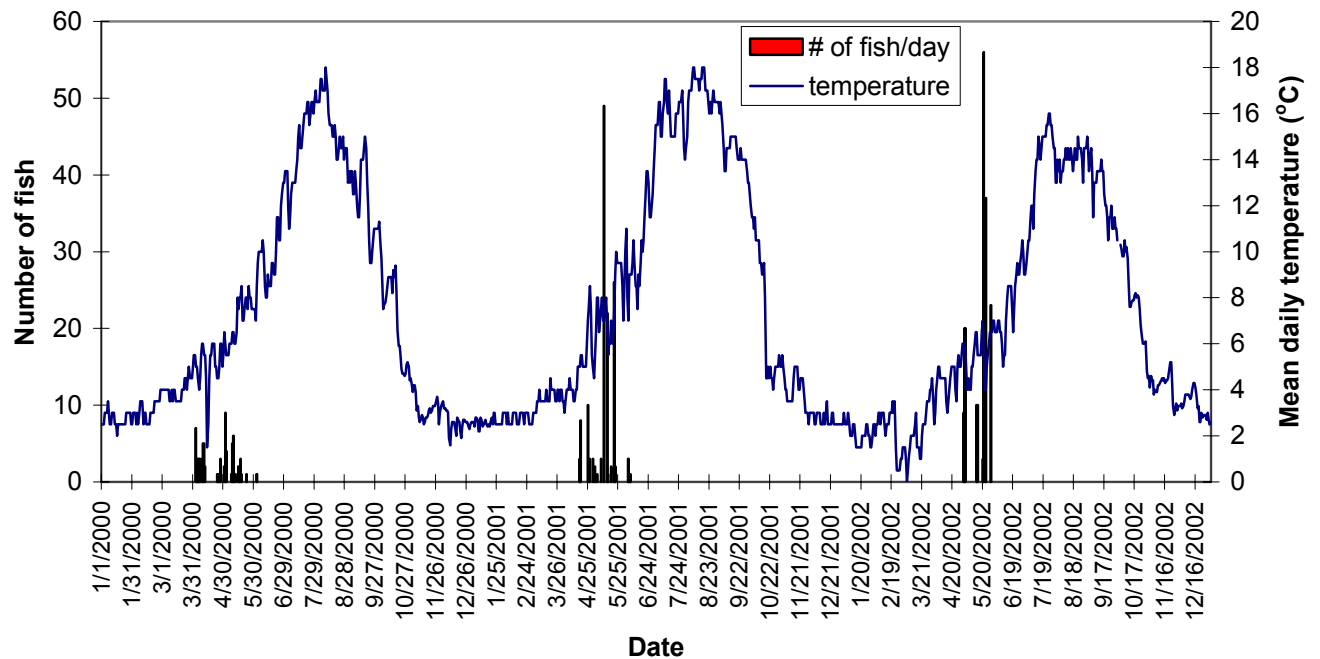
FIGURE 8. Number of fish captured at the Abbot Creek trap as related to Flathead River mean daily temperature (°C) in 2000, 2001, and 2002.

During peak spring flows, the Flathead River created a backwater effect into Abbot Creek that submerged the trap. Consequently, fish were able to circumvent the trap during these peak flow events. On 21, 23, and 28 May 2002 we used boat electrofishing to capture fish in the backwater areas above and below the trap. Out of 190 fish captured in Abbot Creek in 2002, 116 fish were caught with electrofishing equipment while the trap was submerged and ineffective.

Figure 9 shows the length frequency distribution of RBT and WCT x RBT hybrids captured in Abbot Creek for the past three years. Adult spawners range from 325 mm to 475 mm (TL). From 2000 to 2002, a small shift to higher year classes seems to be occurring, probably due to fish removed from the system in 2001 and 2002. Future years of trapping and removal efforts should show a continued shift to older age classes as remaining fish increase in length and recruitment of new age classes is curtailed.

FIGURE 9. Length frequency distributions for rainbow and hybrid trout captured in the Abbot Creek trap during the spring of 2000 ($N = 77$), 2001 ($N = 140$) and 2002 ($N = 188$).

Timing and Location of Spawning by Rainbow trout and Westslope Cutthroat Trout x Rainbow Trout Hybrids

Hybridization between rainbow and westslope cutthroat trout is prevalent in the Flathead River upstream of Flathead Lake (Deleray et al. 1999; Hitt 2002; Hitt et al.-*In* review). Despite recognition of apparent population declines, little is known about the spatial and temporal distribution of na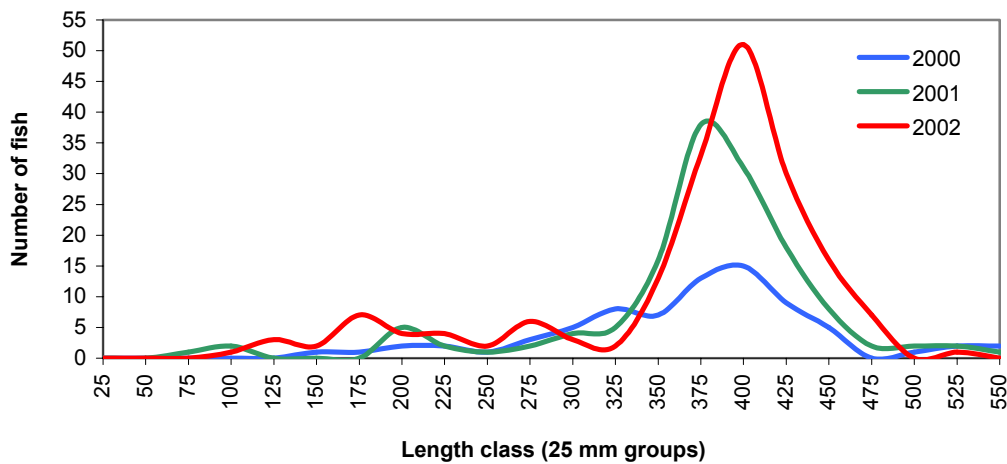tive westslope cutthroat trout and non-native rainbow trout during spawning. An understanding of fish movements during spawning will allow managers to identify mechanisms responsible for genetic introgression and identify streams containing hybrids for removal or suppression programs by the Hungry Horse Mitigation Program.

Telemetry

Radiotelemetry was used to monitor movements of 26 adult fish (343 – 545 mm T.L.) during the spring of 2002. Fish were captured by boat electrofishing, surgically implanted with radio transmitters, and released near their capture location. We use Lotek MCFT-3CM coded transmitters which weighed 6.7g (air weight) and emitted a unique code in the 148.440 MHZ frequency range.

Fish were relocated five times per week during the spawning and three times per week during the migration phases of the spawning period. We located fish using a Lotek (model SRX 400) scanning receiver equipped with an ATS 3-element Yagi antenna from a jet boat and from vehicle access points along the stream. Fixed wing aerial telemetry was used to survey remote and inaccessible areas throughout the upper portions of the Flathead River system. When logistically possible, observers walked spawning tributaries to gain a more accurate location and to document redd construction. A telemetry ground station was installed approximately 4 km upstream of the South Fork that was used to continuously monitor (24-hours/7 d per week) when fish came within 250 m of the station. The ground station consisted of a Lotek data-logging receiver equipped with a 3-element directional Yagi antenna powered by a 12-volt deep-cycle marine battery.

Due to high spring flows and turbid stream conditions during the spawning period, we were unable to physically document exactly where and when the fish spawned. Therefore, we established a set of criteria to estimate the location and timing of spawning. All fish that moved into tributaries during the spawning period were assumed to have spawned. All fish that remained in close proximity to their respective capture and release locations in the main stem Flathead River were classified non-spawners. Fish that made pronounced migrations, were relocated several times near the same tributary mouth and then migrated back to their pre-spawn tagging locations were assumed to have spawned. We assumed that fish spawned within their furthest upstream or downstream location during the fish's migration. Spawning periods for each group were defined as the time period between when the first and last fish spawned.

Molecular Genetics

Tissue samples were collected from each fish during surgery, preserved in 95% ethanol, and later sent to the Wild Salmon and Trout Genetics Laboratory at the University of Montana, Missoula. We used molecular analyses using 10 diagnostic markers produced from random amplified polymorphic DNA to determine the genetic composition of each study fish. We also estimated the taxonomic identity of each fish using meristic characteristics. Visual techniques relied on the spotting pattern, body coloration, and the presence or absence of coloration (e.g. red slashes) below the gill covers. Although success at visually differentiating between RBT and hybrid fish is at best marginal, past studies have shown excellent success at identifying pure WCT. This suggests that removal efforts using visual examination may prove to be successful in reducing the abundance of RBT and hybrids in the system.

Results and Discussion

Genetic analyses confirmed that we radio tagged 18 RBT and 8 hybrids in the main-stem Flathead River near Kalispell and Columbia Falls (mean T.L.= 402mm; range: 343 – 545mm). Fish were relocated an average of 20 times (range, 11-32).

Of the 26 tagged RBT and hybrids, 2 transmitters failed prematurely and 3 fish made no migratory movements during the study period. Of the 21 remaining fish, 19 were relocated at the mouth of or within spawning tributaries (spawners) and 2 fish made significant upstream migrations but were not tracked to spawning streams (probable spawners).

Spawning behavior

RBT and hybrid fish began spawning migrations between 30 March and 16 May 2002 (median = April 14th) as water temperature increased and ranged from 1 to 6.5^{o}C. Fish entered spawning tributaries between 14 April and 15 June (median = 20 May). Fish staged at tributary mouths from 2 to 25 days (mean = 8 d). The average amount of time spent in spawning streams was 7 days (range, 1–19 d). The median spawn date was 23 May (range, 15 April-22 June; Figure 10).
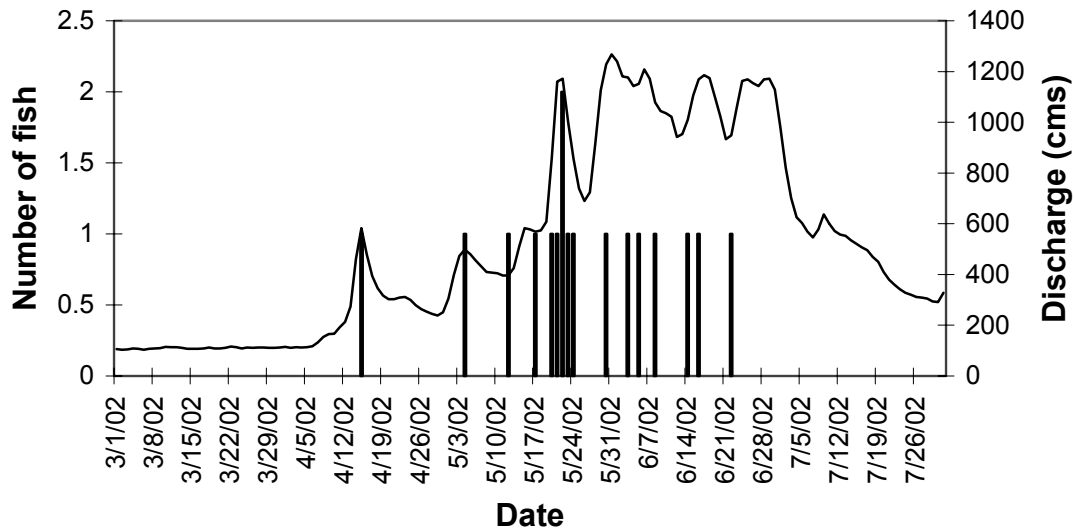
FIGURE 10. Number of spawners and dates each fish spawned as related to the main-stem Flathead River hydrograph in 2002.

As in previous years, Abbot Creek continues to be the major spawning stream for RBT and hybrids radio-tagged in the main-stem Flathead River. Twelve of the 18 implanted fish (67%) spawned in Abbot Creek in 2002. Molecular genetic analyses revealed 11 RBT and 1 hybrid fish. In 2003, a permanent fish barrier will be installed in the Highway 2 culvert impede upstream migration to spawning areas.

Radio-tagged fish utilized two other main-stem tributaries in 2002. One RBT spawned in "Taylor's Outflow Creek" on 4 May 2002. This is a small spring creek system that enters the Flathead River approximately 300 m upstream of the Highway 2 Bridge. The second RBT was relocated in "Blankenship Creek", a small un-named tributary entering the Flathead River from the west side just below the confluence of the North and Middle Forks. Three redds were also documented in this stream during a survey completed on 21 June 2002.

The North Fork of the Flathead River provided 3 spawning streams for radio-tagged hybrid trout in 2002. One hybrid fish entered and spawned in "Steamer Creek on 5 June and another hybrid spawned in "Third Creek" on 16 June. Both of these officially un-named streams are located in Glacier National Park (GNP) and are found approximately 5 km upstream of the confluence with the Middle Fork. The third hybrid spawned in Hay Creek on 12 May. Hay Creek enters the North Fork from the west side and is approximately 45 km upstream of the confluence with the Middle Fork.

The two remaining fish spawned in streams of the Middle Fork in 2002. Hybrid #13 migrated upstream from the Kalispell section of the Flathead River to the mouth of McDonald Creek. This drainage is located in GNP near West Glacier, Montana and enters the Middle Fork 7.5 km above it's confluence with the North Fork. This fish is assumed to have spawned in McDonald Creek after spending 14 days at the mouth prior

to moving back downstream. Hybrid # 14 entered and spawned in Lincoln Creek on 21 May. Lincoln Creek is located entirely in GNP, and enters the Middle Fork approximately 19 km upstream of the confluence with the North Fork.

The last two fish exhibited migratory behavior but were not relocated near a spawning stream. RBT #11 migrated up the North Fork from the Kalispell section of the Flathead River. This fish was relocated several times in the first few kilometers of the North Fork, and may have used either Steamer or Third Creeks for spawning. RBT #16 was found several times in an area of the upper mainstem near the site of a former private RBT hatchery.

Flathead River Winter Trout Abundance

Salmonid populations exhibit complex movement patterns throughout the upper Flathead River system. The migrational behaviors of native bull trout and westslope cutthroat trout populations are critical to maintain genetic diversity and dispersal among populations, which is critical to the long-term persistence of each species (Allendorf and Leary 1988; Rieman and McIntyre 1995). Determining population status for these species is difficult in the upper Flathead River system due to the timing of seasonal migrations and overlapping habitat use by the different life histories. Further, within a species, individual fish of one life history are generally not visually distinguishable from those of another life history.

Native westslope cutthroat trout and bull trout exhibit both resident (i.e., remaining in natal streams throughout life) and migratory life history strategies (Shepard et al. 1984; Liknes and Graham 1988; Fraley and Shepard 1989; Muhlfeld et al. 2003), while nonnative rainbow trout appear to be primarily fluvial (Muhlfeld et al. 2001, 2002, and 2003). Migratory westslope cutthroat trout rear in their natal stream for 1-4 years, and then migrate downstream as subadults to Flathead Lake (e.g., adfluvial) or the main-stem Flathead River (e.g., fluvial) in the spring, summer, and fall. Adult westslope cutthroat trout generally overwinter in the lower river or the lake, and then migrate long distances upstream (up to 250 km) during high spring flows to access natal spawning streams in the headwaters. Similarly, juvenile bull trout emigrate from tributaries to the Flathead River and Lake system from early summer through winter. Adult adfluvial bull trout migrate from the lake into the river and move toward staging areas in early summer (April-July); move into spawning tributaries generally in August; and move rapidly back downstream to the river or lake during September (Shepard et al. 1984). In contrast, rainbow trout occupy relatively small home ranges in the main stem, moving upstream in the spring to access spawning areas located in the lower and middle portions of the Flathead drainage. Thus, at any time of the year, different salmonids, life histories, and age groups are migrating throughout the river system. These migrations compromise general assumptions of mark-recapture methodologies and complicate standardizing the timing of annual monitoring surveys. This is especially true for the cutthroat and bull trout populations, but not for rainbow trout.

Native bull trout and westslope cutthroat trout populations have declined throughout their range due to human impacts on the environment. Hybridization between native westslope cutthroat trout and nonnative rainbow trout is a leading factor contributing to the decline of genetically pure cutthroat trout populations in the upper Flathead River system. Therefore, we have initiated several projects to suppress and eradicate rainbow trout and hybrid source populations in the lower Flathead River system upstream of Flathead Lake (i.e., Abbot Creek). Monitoring population trends for rainbow trout and hybrids in the main-stem Flathead River will provide managers the proper long-term information to determine the effectiveness of westslope cutthroat trout enhancement efforts.

From 1979-1981 catch per unit effort (CPUE) electrofishing surveys were conducted in two sections of the Flathead River (McMullin and Graham 1981). In an effort to assess fish populations and avoid the above constraints, monitoring efforts were spread out over an extended time period (months) to encapsulate the migration periods. Past methods attempted to describe the relative abundance of these fishes and specific size groups at a number of different times throughout the year. It was believed that repeated sampling (biweekly) would account for annual variation in the timing of seasonal migrations. As a result, in 1997 and 1998, Deleray et al. (1999) followed the methodology of previous surveys (McMullin and Graham 1981; Deleray et al. 1999) to assess changes over the last two decades in westslope cutthroat trout, rainbow trout, and bull trout abundances in the main stem Flathead River near Columbia Falls and Kalispell. The authors recommended that future population surveys should focus on estimating rainbow trout abundance to document population trends as related to suppression programs. Therefore, our 2000-2002 objectives were: (1) to continue monitoring trout catch during winter months in two sections of the main stem Flathead River; and (2) to estimate the abundance of juvenile and adult rainbow trout and hybrids overwintering in the Flathead River.

Methods

We conducted fish population surveys in the main-stem Flathead River following the methodology of previous surveys during the winters of 2000, 2001 and 2002 (McMullin and Graham 1981; Deleray et al. 1999). Two sections of the Flathead River were sampled at one-week intervals; the Kalispell section (2.6 km) near Montana Highway 35 Bridge and the Columbia Falls section (2.0 km) near the Montana Highway 2 Bridge (Figure 1). In 2000, the Kalispell section was shortened (2.95 to 2.6 km) to reduce sampling effort. In 2001 and 2002, we decided to reduce the frequency of sampling in each section to two sampling surveys at least one week apart to obtain a more accurate population estimate (mark-recapture) for rainbow trout and hybrids.

We electrofished at night from a jet boat rigged with fixed-boom anodes. Surveys were started after sunset and continued until we completed two passes on each bank (four passes total) in the section per night. The Coffelt M22 produced straight DC at 3 to 5 amperes. McMullin and Graham (1981) did not specify the wave form or type and power levels used during electrofishing sampling. Most likely, a pulsed DC waveform (60 Hz per second) was used. In recent years, MFWP has established electrofishing policy

which dictates use of straight DC or pulse rates $\leq$ 30 Hz per second when sampling waters with native fishes. This variance in methodology could affect CPUE comparisons between the two sampling periods. Passes began at the upstream boundary of each section and progressed downstream along one of the banks to the lower boundary. We netted all trout, measured total length and weight, and collected scales and genetic samples from cutthroat trout and rainbow trout. All rainbow trout and hybrids were marked (fin clip) to complete a mark-recapture abundance estimate in 2000 (Schnabel multiple census; Ricker 1975), and 2001 and 2002 (Peterson mark-recapture; Ricker 1975).

We calculated CPUE in two ways. In the first, used by McMullin and Graham (1981), CPUE was calculated as the number of a fish species or size group captured divided by the time (hr) spent electrofishing and the length of the sample section (km). McMullin and Graham (1981) graphically displayed CPUE values. We estimated values from figures and, therefore, these values are the best available to compare with the 1997 and 1998 calculated values. The second method used to calculate CPUE was to divide the number of a fish species or size group captured by the time (hr) spent electrofishing. Catch per hour was reported only for rainbow trout in the 1980s report.

Results and Discussion

2000

During the winter of 2000, westslope cutthroat trout, rainbow trout and bull trout dominated the trout and char catch. In both sections combined, we captured 809 westslope cutthroat trout (50%), 690 (43%) rainbow trout and hybrids, and 123 bull trout (7%). In the Columbia Falls section, rainbow trout dominated the total catch (n = 403; 72%) followed by westslope cutthroat trout (n = 126; 23%) and bull trout (n = 28; 5 %). Conversely, in the Kalispell section, westslope cutthroat trout dominated the total catch (n = 683; 64%) followed by rainbow trout (n = 287; 27%) and bull trout (n = 95; 9%).

We caught cutthroat trout in a wide range of sizes, ranging from 100 to 525 mm (TL) during the winter of 2000 (Figure 2). Length frequency analyses revealed one distinct peak in the distribution, representing both juvenile and adult size classes present in the migratory population. Smaller-sized fish were classified as juvenile fish that were either migrating through the river system toward the lake or residing in the river. Larger fish represented the spawning migration of adfluvial adults from Flathead Lake or fluvial adults from the Flathead River. For rainbow trout, we caught a wide range of sizes with good representation of many size groups (Figure 3). Rainbow trout ranged from 82 to 526 mm. We caught bull trout in a wide range of sizes (Figure 4). McMullin and Graham (1981) and Deleray et al. (1999) reported similar results. These data suggest that a fluvial life-history component of the migratory population may occupy the upper Flathead River drainage that may be critical to the long-term persistence of this population given the recent food web changes in the Flathead Lake ecosystem.

Our 2000 results suggest that catch rates for rainbow trout were higher as compared to previous years in the main stem Flathead River (Figures 5 and 6). In both sections, mean rainbow trout catch rates steadily increased from 1981 to 2000, ranging from 2.5 fish/km/hr in 1981 to 14.5 fish/km/hr in 2000. Similarly, catch rates for westslope cutthroat trout appeared to be higher as compared to previous years. In both monitoring sections, CPUE for bull trout in 2000 were relatively consistent as compared to previous surveys.

Our estimates from 1997, 1998 and 2000 suggest that the abundance of rainbow trout and hybrids increased in the Columbia Falls section of the Flathead River (Figure 7). In the 2.0 km Columbia Falls section, we estimated that there were 145 fish (<200 mm)/km (97, 228 95% CI), 166 fish (200-400 mm)/km (129, 214 95% CI) and 19 fish (>400 mm)/km (95% CI not available). In the 2.6 km Kalispell section, we estimated that there were 40 fish (<200 mm)/km (22, 81 95% CI) and 193 fish (200-400 mm)/km (136, 285 95% CI). We were unable to estimate the abundance of fish greater than 400 mm because we only caught 1 fish during the sampling period.

2001

Westslope cutthroat trout, rainbow trout and bull trout dominated the trout and char catch in the winter of 2001. In both sections combined, we captured 215 westslope cutthroat trout (48%), 210 (48%) rainbow trout or hybrids, and 16 bull trout (4%; Table 1). In the Columbia Falls section, rainbow trout dominated the total catch (n = 148; 66%) followed by westslope cutthroat trout (n = 72; 32%) and bull trout (n = 6; 3%). Conversely, in the Kalispell section, westslope cutthroat trout dominated the total catch (n = 143; 67%) followed by rainbow trout (n = 62; 29%) and bull trout (n = 10; 5%).

We caught cutthroat trout in a wide range of sizes, ranging from 125 to 440 mm (TL) during the winter of 2001 (Figure 2). For rainbow trout, we caught a wide range of sizes with good representation of many size groups (Figure 3). Rainbow trout ranged from 98 to 695 mm in length. Subadult and adult bull trout were present in the sample (Figure 4); total lengths ranged from 252 to 755 mm. McMullin and Graham (1981), Deleray et al. (1999), and Muhlfeld et al. (2001 and 2002) reported similar results.

In both sections, CPUE values for rainbow trout and cutthroat trout were slightly lower in 2001 as compared to those reported in 2000 in the Flathead River (Figures 5 and 6). However, trends CPUE indicate an overall increase in rainbow abundance since 1981. In the Columbia Falls section, rainbow trout catch rates increased from 1981 (2.5 fish/km/hr) to 1998 (10.7 fish/km/hr), peaked in 2000 (14.5 fish/km/hr), and were 12.5 fish/km/hr in 2001. Similarly, catch rates for westslope cutthroat trout remained relatively high, while bull trout catch rates were similar to previous surveys.

Abundance estimates for rainbow trout and hybrids (>200 mm) in the main-stem Flathead River were similar to those reported in 2000 (Figure 7). However, in the Columbia Falls section, the abundance of fish less than 200 mm declined from an estimated 145 fish/hr in 2000 to 53 fish/km in 2001. The decline in abundance of rainbow and hybrid trout less

than 200 mm in the Columbia Falls section may be due to the physical removal of rainbow trout and hybrids in Abbot Creek during 2000. In the 2.0 km Columbia Falls section, we estimated that there were 53 fish (<200 mm)/km (23,131 95% CI), 244 fish (200-400 mm)/km (109, 609 95% CI), and 4 fish (>400 mm)/km (1,7 95% CI). In the 2.6 km Kalispell section, we estimated that there were 8 fish (<200 mm)/km (2,8 95% CI), 46 fish (<200-400 mm)/km (22,107 95% CI), and 1 fish (> 40mm)/km (0,1 95% CI).

2002

Westslope cutthroat trout, rainbow trout and bull trout dominated the trout and char catch during the winter of 2002. In both sections combined, we captured 171 rainbow trout or hybrids (54%), 111 westslope cutthroat trout (35%), and 35 bull trout (11%). In the Columbia Falls section, rainbow trout dominated the total catch (n = 125; 64%) followed by westslope cutthroat trout (n = 56; 29%) and bull trout (n = 14; 7%). Conversely, in the Kalispell section, westslope cutthroat trout dominated the total catch (n = 55; 45%) followed by rainbow trout (n = 46; 38%) and bull trout (n = 21; 17%).

We caught cutthroat trout in a wide range of sizes, ranging from 171 to 502 mm (TL) during winter 2002 (Figure 2). Analyses revealed one distinct peak in the length frequency distribution, representing the sub-adult size class, of the migratory population. For rainbow and hybrid trout, we caught a wide range of sizes with good representation of many size groups (Figure 3). Rainbow trout and hybrids ranged from 95 to 441 mm in length. Subadult and adult bull trout were present in the sample; lengths ranged from 177 to 691 mm (Figure 4). McMullin and Graham (1981), Deleray et al. (1999), and Muhlfeld et al. (2001 and 2002) reported similar results.

Our electrofishing catch data indicate that abundances of westslope cutthroat trout and bull trout were relatively consistent from 2000 to 2002 (Figures 5 and 6). Further, comparisons of CPUE (#km/hr) for cutthroat trout and bull trout between the early 1980s surveys and the late 1990s and early 2000s did not exhibit an obvious change in abundance. In the Columbia Falls section, CPUE values declined for rainbow, cutthroat, and bull trout in 2001 and 2002 (Figure 1). Catch rates for rainbow trout peaked to 14.5 fish/km/hr in 2000 but have declined in both 2001 (12.5 fish/km/hr) and 2002 (7.6 fish/km/hr). Westslope cutthroat trout showed a moderate decline from 2001 (5.3 fish/km/hr) to 2002 (3.4 fish/km/hr). Conversely, catch rates for 2002 in the Kalispell section rose for rainbow trout and bull trout and showed only a slight decline for cutthroat trout.

Our 2002 estimates indicate a sharp decline in rainbow and hybrid trout abundance for all size-classes in the Columbia Falls section of the Flathead River (Figure 7). In the 2.0 km Columbia Falls section, we estimated that there were 28 fish (<200 mm)/km (16,55 95% CI), 62 fish (200-400 mm)/km (36,146 95% CI), and 5 fish (>400 mm)/km (1,5 95% CI) (Figure 2). Abundance estimates were unable to be calculated for the Kalispell section in 2002 due to inclement weather during the recapture period.

The potential decline in rainbow and hybrid trout abundance in the Columbia Falls section of the Flathead River may be due to the physical removal of rainbow trout by trapping and electrofishing during the spring spawning period at the mouth of Abbot Creek. Relatively higher catch rates in previous years for rainbow trout in the Columbia Falls section may reflect the close proximity of source populations of rainbow and hybrid trout (i.e. Abbot Creek) or individuals that escaped from Sekokini Springs Hatchery when it was in operation as a private rainbow trout hatchery.

Our electrofishing catch information should be viewed with caution, primarily for cutthroat trout and bull trout. Changes in catch rates may reflect 1) fluctuations in trout abundance over time, 2) variations in sampling efficiency (due to changes in river discharge), or 3) differences in the timing of seasonal migrations. Managers should evaluate other population indices to accurately assess the status of salmonid populations inhabiting the upper Flathead River system.
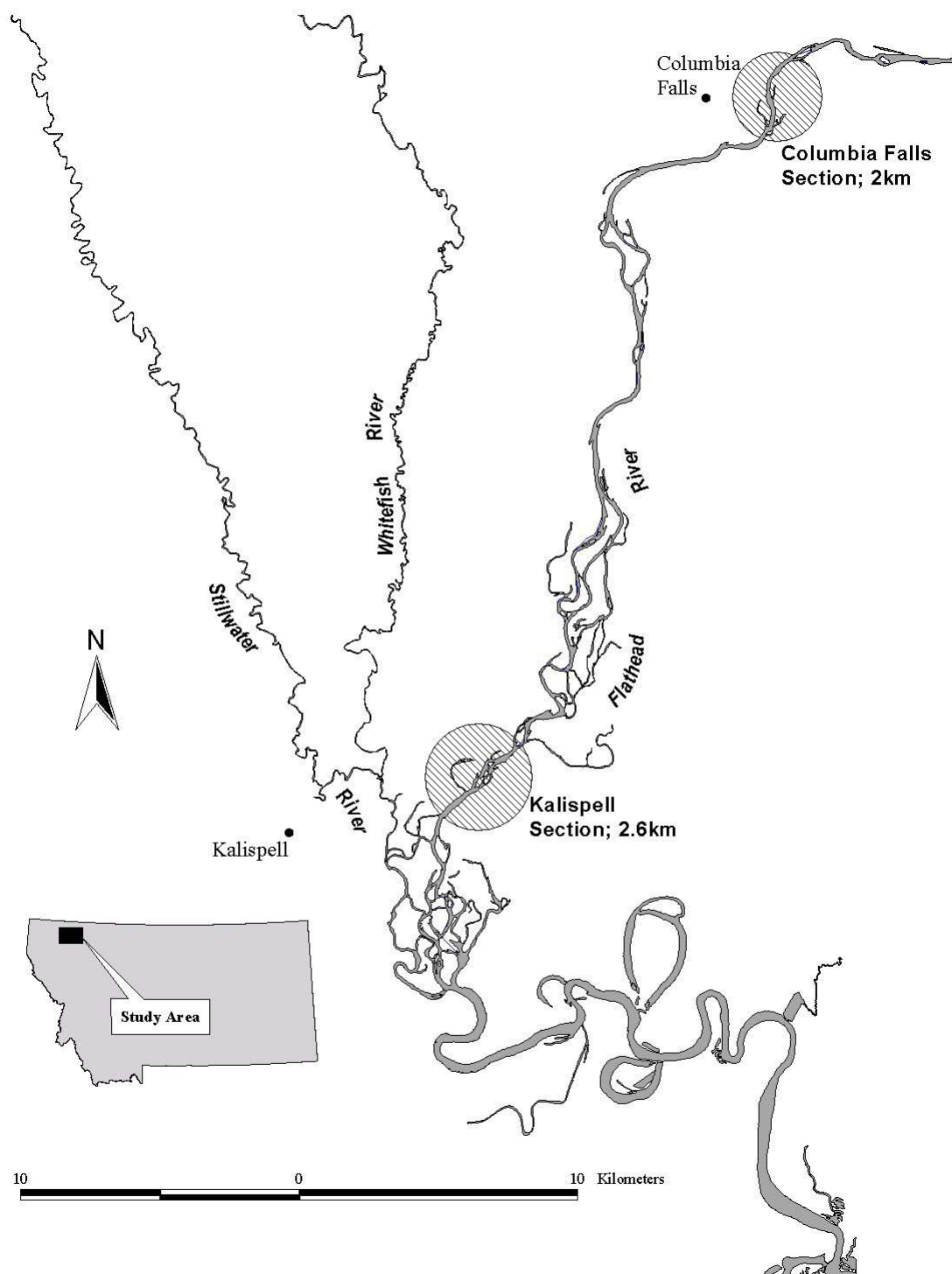
FIGURE 1. Winter electrofishing sections in the main-stem Flathead River.
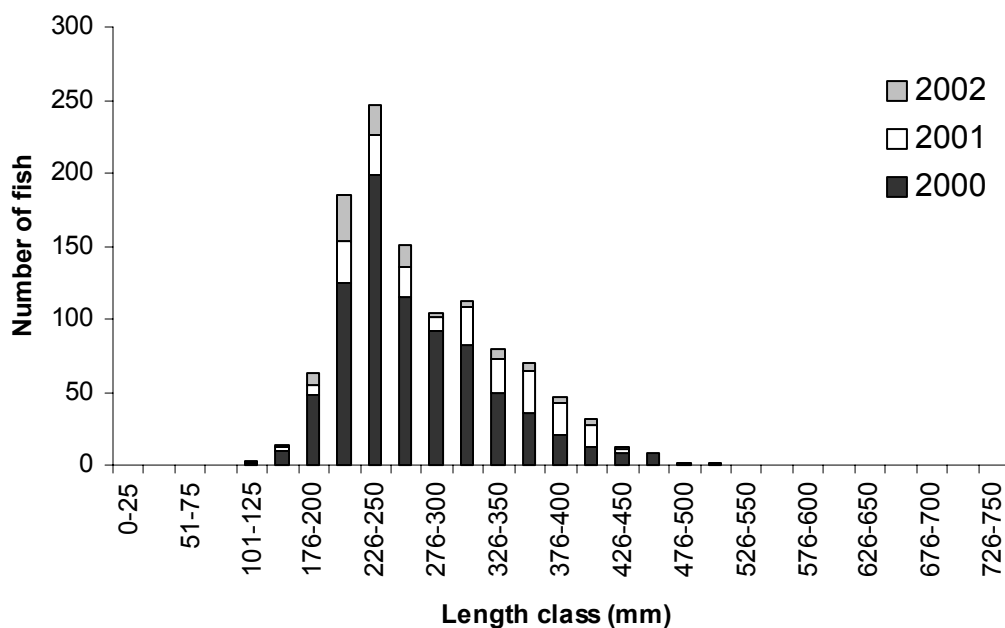
FIGURE 2. Length frequency distribution for westslope cutthroat trout captured during electrofishing surveys on the main-stem Flathead River during February and March of 2000 ($N = 809$), February and March of 2001 ($N = 215$), and March of 2002 ($N = 111$).
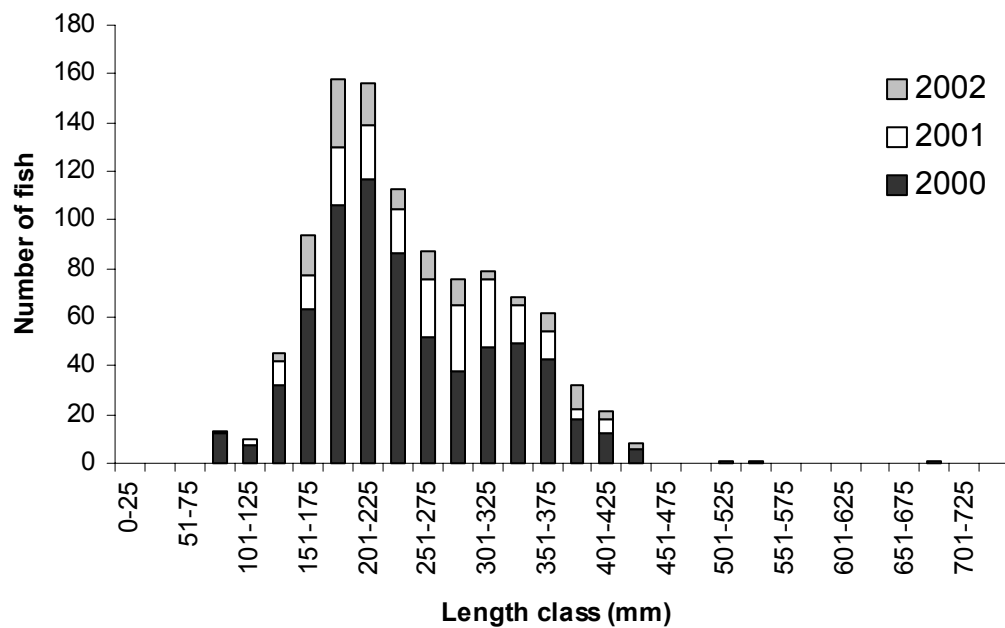
FIGURE 3. Length frequency distribution for rainbow trout captured during electrofishing surveys on the main-stem Flathead River during February and March of 2000 ($N = 690$), February and March of 2001 ($N = 210$), and March of 2002 ($N = 125*$).

*Columbia Falls section only.
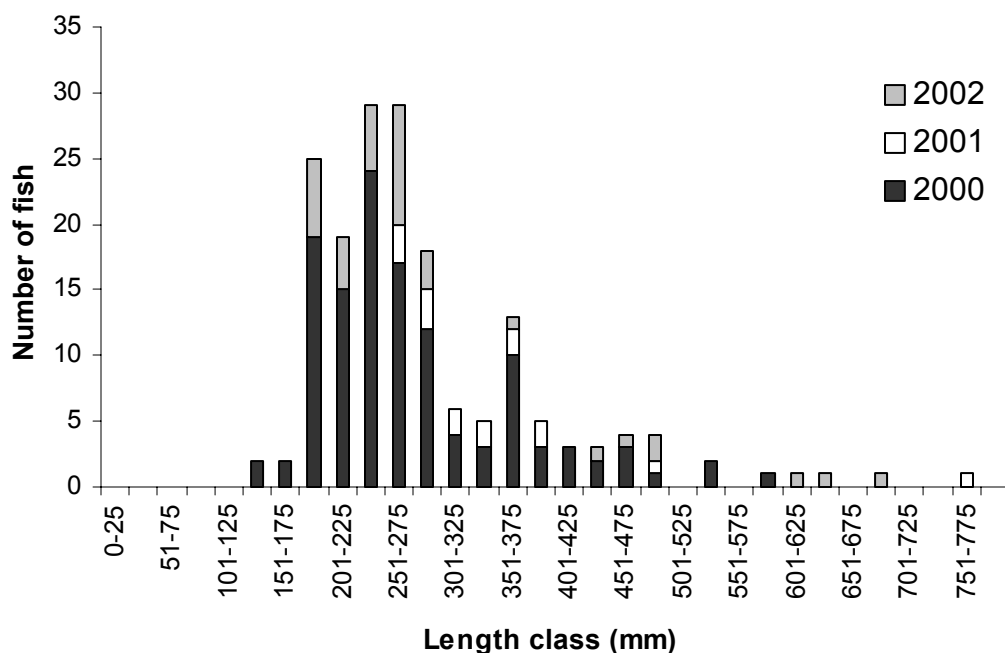
FIGURE 4. Length frequency distribution for bull trout captured during electrofishing surveys on the main-stem Flathead River during February and March of 2000 ($N = 123$), February and March of 2001 ($N = 16$), and March of 2002 ($N = 35$).
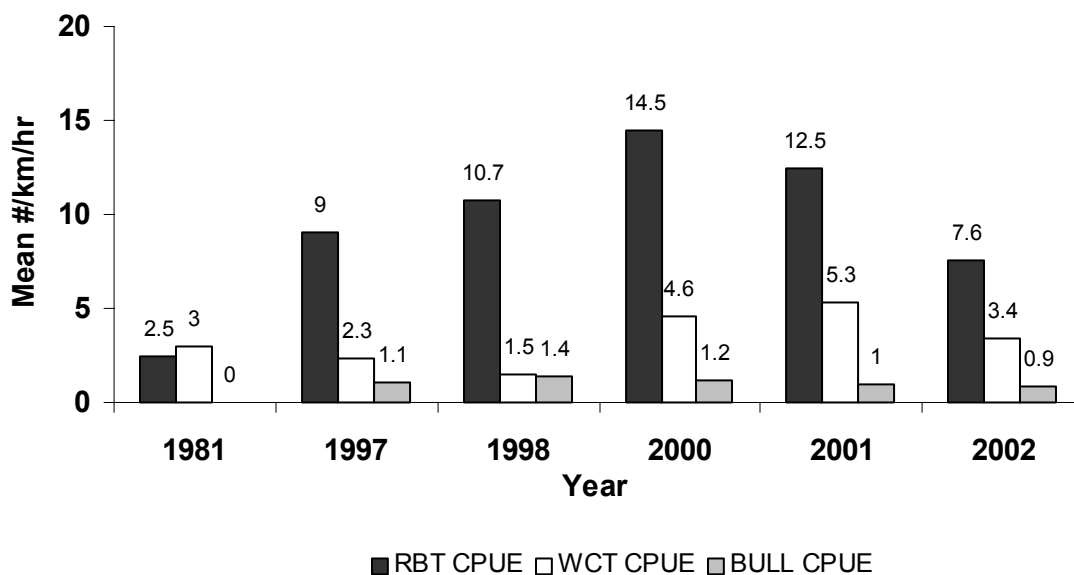
FIGURE 5. Mean catch per unit effort (CPUE) for rainbow, westslope cutthroat, and bull trout captured during winter electrofishing surveys in the Columbia Falls section of the Flathead River in 1981, 1997, 1998, and 2000 – 2002.
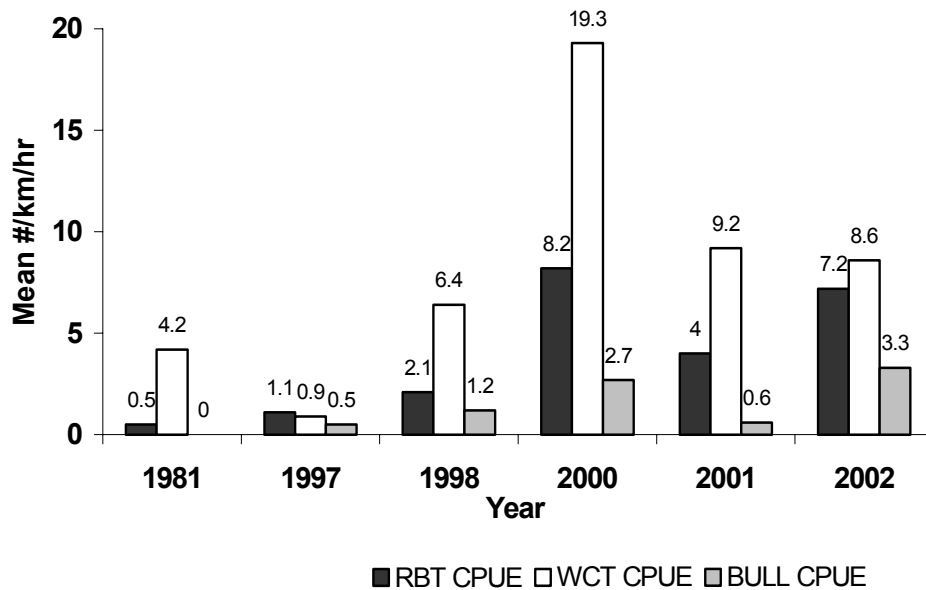
FIGURE 6. Mean catch per unit effort (CPUE) for rainbow, westslope cutthroat, and bull trout captured during winter electrofishing surveys in the Kalispell section of the Flathead River in 1981, 1997, 1998, and 2000 – 2002.
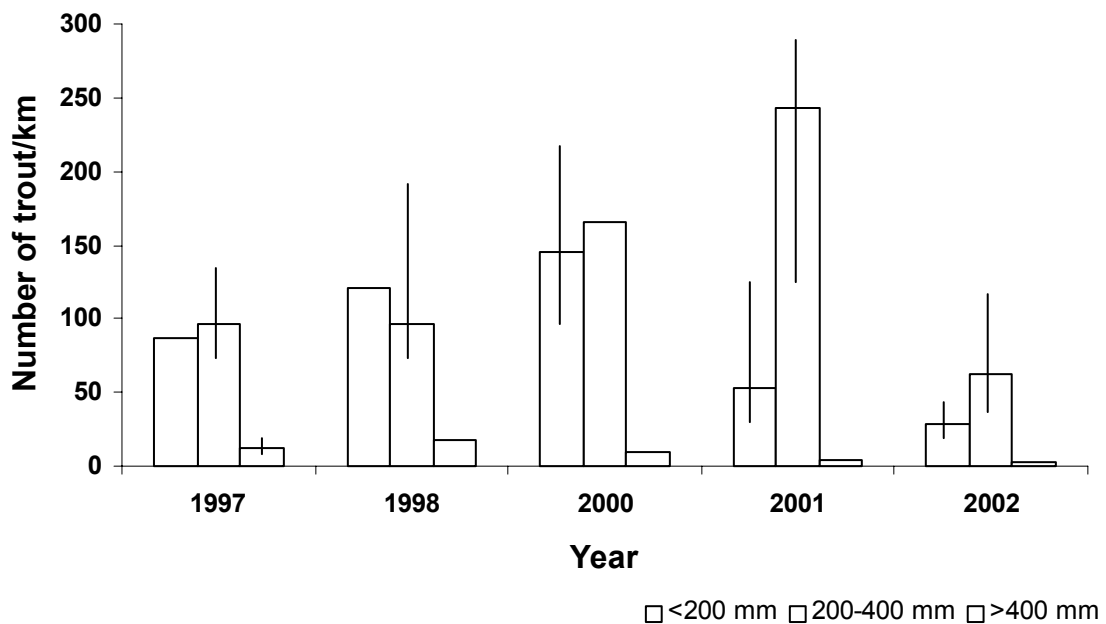
FIGURE 7. Abundance estimates for rainbow and hybrid trout in the Columbia Falls section of the Flathead River during the winters of 1997, 1998, 2000 (Schnable; Ricker 1975), 2001 and 2002 (Peterson; Ricker 1975). Bars indicate 95% confidence intervals.

Using Trace Element Compositions of Juvenile Westslope Cutthroat Trout Scales to Determine Stream Origin in the upper Flathead River system

In 2001, the Hungry Horse Mitigation Program began to develop and test a non-lethal technique to determine stock origin and life history of native migratory westslope cutthroat trout populations inhabiting the upper Flathead River drainage, Montana. The objective is to use laser ablation coupled with plasma mass spectrometry for micro-elemental analysis of WCT scales to distinguish stock structure and understand life history (Wells et al. 2000). This technique examines specific parts of individual scales limits of detection less than 100 µg/g (Thorrold and Shuttleworth 2000) and requires a suite of elemental analyses (i.e. Sr, Mg, Ca, Ba, Mn etc.) to establish baseline signatures for different streams. This technique is non-lethal (only one scale is needed), and it may be the most effective method to differentiate trace element signatures in stream-dwelling salmonid populations due to the relatively large differences in geomorphology and lack of mixing between stream systems. If successful, researchers will be able to sub-sample adult fish within a population to determine where the majority of genetically pure fish are originating (for protection of critical habitats). Sources of genetically introgressed fish will be identified for mitigation efforts and fish originating from restored sites can be identified for monitoring purposes. This technique may be applied to other stream systems containing resident salmonid populations throughout the Pacific Northwest.

Passive chemical or natural marks may provide a solution to describe the distinctly different environments fish encounter throughout their life. Trace-element analysis of otoliths and scales has proven to be effective for retrospectively describing the environmental history of individual fish and metapopulation dynamics. However, much of this work has focused on in estuarine and marine waters. Our interest has been to adapt these methods to describe fish movements wholly within freshwaters using a non-lethal technique to determine stock origin.

Rieman et al. (1994) used otolith microchemistry to discriminate *O. nerka* of resident and anadromous origin. Otolith analyses work well to track the elemental concentrations embedded in fish; however, obtaining a sample requires sacrificing the individual fish. Wells et al. (2000) described the geographic variation in trace element compositions of juvenile weakfish scales. Using this technique the authors reported that overall classification accuracy was only 67% and ranged from 38 to 86%. This study provided evidence that this technique may work in freshwater, resident systems.

Applying trace element analysis of fish scales to a freshwater stream environment may prove to be a more accurate technique given the lack of mixing between streams within a basin. Schmetterling and Dawson (D. Schmetterling, personal communication; *In press*) were able to discriminate between the Blackfoot and Clark Fork Rivers using carbon and nitrogen isotope analysis. Further, they were able to discriminate 8 of 12 streams in the study. However, this technique requires obtaining 1 mg of scale material (at a minimum), which is lethal to juvenile salmonids.

Therefore, the goal of this study was to determine the stream origin of westslope cutthroat trout using a non-lethal technique.

Methods

Backpack electrofishing was used to collect juvenile WCT from streams of the upper Flathead River drainage (North Fork, Middle Fork, and South Fork) during 2001 and 2002 (Table 1). Within each stream, fish were collected from an upper site and a lower site to quantify within-stream variation in elemental signatures of the scale. For each captured fish, we removed scales, measured length and weight, and removed tissue samples for genetic analyses.

Laser ablation inductively coupled plasma mass spectrometry was used to analyze the elemental composition of individual scales from each stream. Samples were sent to Simon Thorrold at Woods Hole Laboratory (Massachusetts). Each scale was ablated at the edge and the core representing the last and first summer rearing phase of their life history. At each location, Ca, Sr, Mg, Mn, Ba, and Pb isotope counts were quantified for each scale. The isotopic counts were raised to natural levels, standardize to Ca, and converted to molar ratios.

In conjunction with the fish sampling, we collected water samples at each sampling location to characterize elemental concentrations. Water chemistry analyses followed USGS standard water sampling procedures. For each sample, 50 ml of water was vacuum filtered, preserved with 2 drops of HCL, and later sent to Dr. Johnnie Moore at the University of Montana Geology Laboratory for elemental analysis using a inductively couple plasma optical emission spectrometer.

A   **B**   **C**
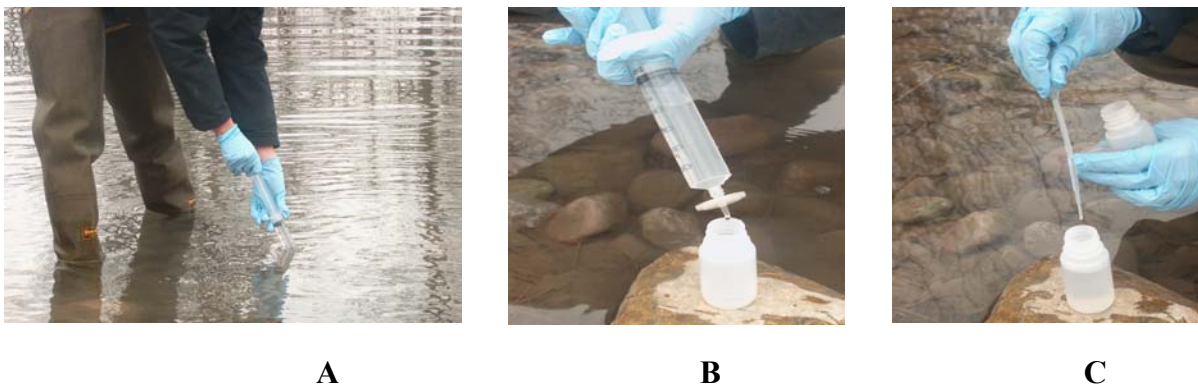
FIGURE 1. Water chemistry analyses followed USGS standard water sampling procedures. For each sample, 50 ml of water was vacuum filtered (A and B) and preserved with 2 drops of HCL (C).
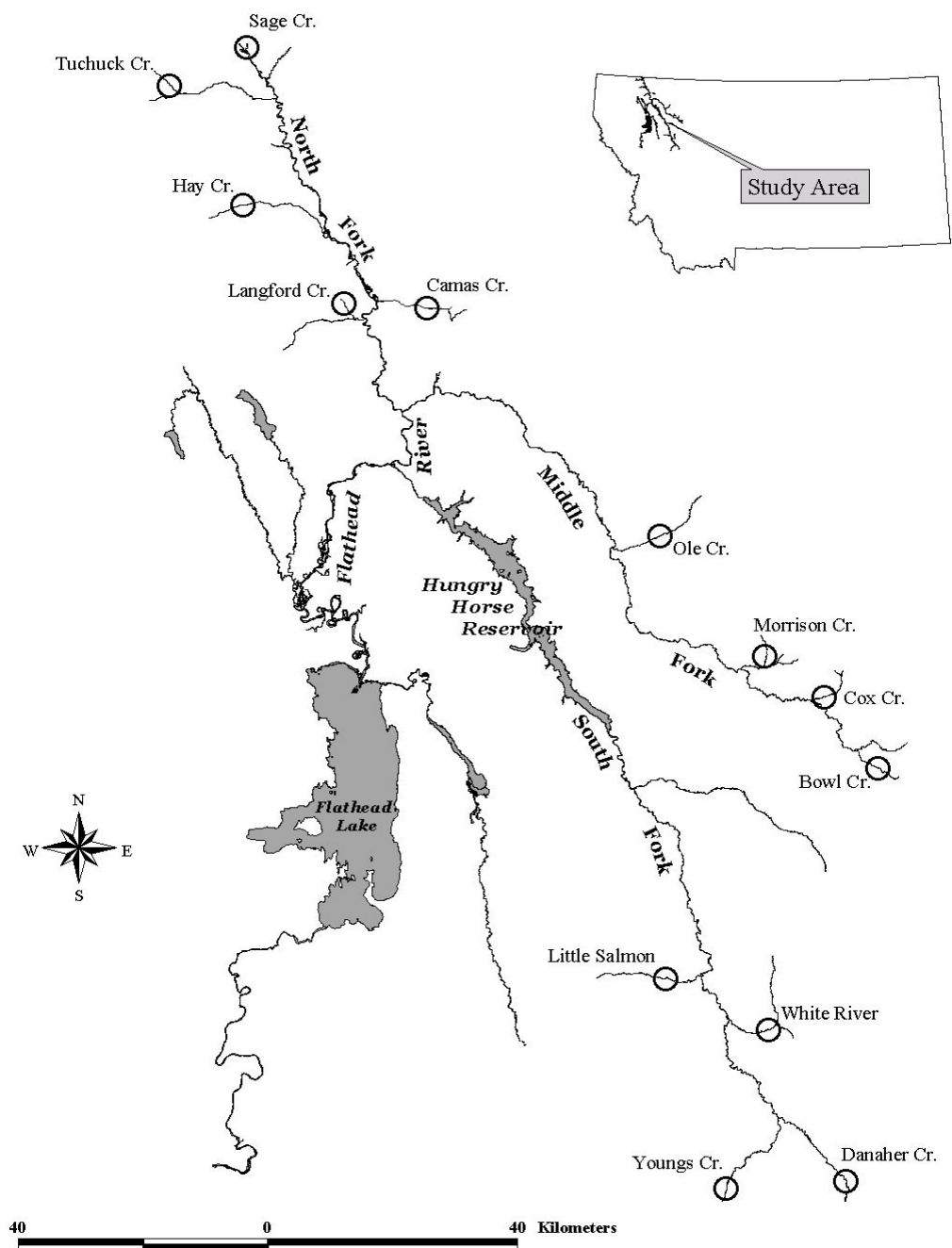
FIGURE 1. Study area streams in the upper Flathead River, Montana.

Results

We quantified Mg:Ca, Mn:Ca, Sr:Ca, Ba:Ca, and Pb:Ca trace element ratios of 291 individual juvenile westslope cutthroat trout scales in 13 streams of the upper Flathead River drainage in 2001 and 2002 (Figure 1). Mean lengths (TL) of juvenile westslope cutthroat trout ranged from 118-245 mm (Table 1). There were significant differences in total length among streams within the North Fork, Middle Fork, and South Fork Flathead River drainages (Table 1). However, none of the element:Ca ratios were significantly related to total length, suggesting that the size of the fish did not influence results of the trace element analyses. The elemental concentrations at the center and edge of the scales were highly correlated for all element:Ca ratios in each drainage (Table 2), indicating that fish were indeed rearing in their respective natal tributaries. Finally, linear regression analysis found that Sr:Ca and Ba:Ca levels in the trout scales were significantly related to those in the water for each drainage (Table 3), whereas there was no significant relationship for Mg:Ca levels ($P < 0.05$).

Trace Element Analysis

There were significant differences in trace element ratios among streams within each drainage of the upper Flathead River basin (Figure 2; Table 4). ANOVA found that all trace element:Ca ratios were significantly different among streams in the North Fork drainage, whereas in the Middle Fork and South Fork drainages there were significant differences among streams for Mn:Ca, Sr:Ca, Ba:Ca, and Pb:Ca ratios, but not for Mg:Ca (Figure 2; Table 4). Multiple comparisons using the Scheffe test revealed that Sr:Ca and Ba:Ca ratios were more useful for differentiating streams in each basin (Figure 2).

We found significant variability in the multivariate elemental signatures between streams within each basin. MANOVA found significant differences in the multivariate elemental signatures among streams within the North Fork (Wilks' Lambda = 0.0266; $P < 0.0001$), Middle Fork (Wilks' Lambda = 0.0221; $P < 0.0001$), and South Fork (Wilks' Lambda = 0.1416; $P < 0.0001$). Differences in the multivariate elemental signatures among streams were visualized using a canonical discriminant analysis. Examination of plots of the first and second canonical variates revealed streams were significantly separated in discriminant space within each drainage (Figure 3). For streams in the North Fork drainage, Camas Creek, Sage Creek, and Hay Creek formed separate groups in discriminant space, but Tuchuck Creek and Langford Creek slightly overlapped. In the South Fork, White River, Youngs Creek, and Danaher Creek separated from each other, while Little Salmon Creek overlapped with the other three streams. Streams in the Middle Fork were clearly separated from each other in discriminant space.

Forward stepwise discriminant function analysis was used to classify juvenile cutthroat trout to their natal tributary based on the multivariate elemental signatures of individual fish scales. Classification of scale elemental signatures indicated that all trace element ratios contributed significantly (Wilks' Lambda < 0.0001) to stream separation in each drainage. In the North Fork drainage, overall classification accuracy was 92%, and ranged from 86% for fish from Tuchuck Creek to 100% for individuals from Sage Creek

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(Table 5). Classification accuracy in the Middle Fork ranged from 96% for fish from Cox Creek to 100% for individuals in Bowl Creek, Morrison Creek, and Ole Creek, with an overall accuracy of 98% (Table 5). Cross-validation classification accuracies were slightly lower in the South Fork, ranging from 72% in White River to 86% in Youngs Creek, with an overall accuracy of 78%. In general, Sr:Ca and Ba:Ca trace element ratios were the most important variables in the first and second discriminant functions (Table 6).

These data indicate that trace element signatures may be used as natural tags to identify natal stream origin of cutthroat trout. In the future, this technique may be used to 1) monitor the effectiveness of habitat and passage programs, 2) identify and protect important populations, and 3) determine life history.

TABLE 1. Sample locations, collection dates, sample sizes, mean total lengths (TL), and standard deviations (SD) for juvenile westslope cutthroat trout in 2001 and 2001.

Drainage or Stream	Date Collected	N	Mean TL	SD
North Fork				
Camas Creek (b)	10 Oct 2001	28	129	22.1
Hay Creek (a)	13 Aug 2001	28	161	30.4
Langford Creek (b)	14 Aug 2001	27	138	47.9
Sage Creek (b)	3 Oct 2001	14	118	23.4
Tuchuck Creek (a)	15 Aug 2001	29	164	21.0
Middle Fork				
Bowl Creek (a)	19 Sep 2002	12	216	31.8
Cox Creek (b)	19 Sep 2002	26	135	29.5
Morrison Creek (b)	16-17 Sep 2002	11	155	32.9
Ole Creek (a)	25 Sep 2002	7	198	43.7
South Fork				
Danaher Creek (b)	27 Aug 2001	13	179	22.9
Little Salmon Creek (a)	21 Aug 2001	26	245	79.5
White River (b)	24 Aug 2001	29	174	34.4
Youngs Creek (a)	24 Aug 2001	29	202	21.8

TABLE 2. Spearman's Rank Order Correlations between the trace element ratio concentrations at the core and rim of individual fish scales within each drainage of the upper Flathead River basin.

Element ratio (core and rim)	Valid *N*	Spearman R	t(*N*-2)	*P*
North Fork				
Mg:Ca	126	0.75	12.63	0.00
Mn:Ca	126	0.87	19.55	0.00
Sr:Ca	126	0.92	26.05	0.00
Ba:Ca	126	0.92	26.89	0.00
Pb:Ca	126	0.68	10.44	0.00
Middle Fork				
Mg:Ca	56	0.26	1.97	0.05
Mn:Ca	56	0.71	7.39	0.00
Sr:Ca	56	0.83	10.73	0.00
Ba:Ca	56	0.75	8.26	0.00
Pb:Ca	56	0.79	9.40	0.00
South Fork				
Mg:Ca	109	0.52	6.30	0.00
Mn:Ca	109	0.89	20.49	0.00
Sr:Ca	109	0.83	15.23	0.00
Ba:Ca	109	0.87	18.38	0.00
Pb:Ca	109	0.63	8.47	0.00

TABLE 3. Linear regression analysis table demonstrating that Sr:Ca and Ba:Ca levels in the trout scales were significantly related to those in the water for each drainage.

Watershed and Element ratio	R^2	Equation	*F*	df	*P*
North Fork					
Sr:Ca	0.87	y = 133232x - 23.29	19.32	3	0.0218
Ba:Ca	0.78	y = 21492x + 89.81	10.30	3	0.0490
Middle Fork					
Sr:Ca	0.93	y = 99337x - 37.26	28.38	3	0.0335
Ba:Ca	0.91	y = 12868x + 56.688	20.04	3	0.0465
South Fork					
Sr:Ca	0.98	y = 69445x + 91.061	87.23	3	0.0113
Ba:Ca	0.96	y = 19566x + 65.939	46.74	3	0.0207

TABLE 4. Individual analysis of variance (ANOVA) tables for each trace element ratios quantified in juvenile westslope cutthroat trout scales from streams in the North Fork, Middle Fork, and South Fork Flathead River drainages. Each ANOVA was done using log-transformed values for each element ratio; however, actual mean values are reported in the table. Means for Mg:Ca are mmol/mol, and means for Mn:Ca, Sr:Ca, Ba:Ca, and Pb:Ca are umol/mol.

Element Ratio	Mean Square	*F*	df	*P*
		North Fork		
Mg:Ca	0.5427	7.86	4	0.0000
Mn:Ca	0.5473	24.97	4	0.0000
Sr:Ca	0.9848	94.67	4	0.0000
Ba:Ca	1.2672	48.53	4	0.0000
Pb:Ca	2.1620	9.49	4	0.0000
		Middle Fork		
Mg:Ca	0.0107	2.18	4	0.1009
Mn:Ca	0.2482	14.15	4	0.0000
Sr:Ca	0.5876	135.28	4	0.0000
Ba:Ca	0.8120	41.59	4	0.0000
Pb:Ca	0.8219	5.36	4	0.0000
		South Fork		
Mg:Ca	0.0077	1.61	4	0.1910
Mn:Ca	2.1207	48.20	4	0.0000
Sr:Ca	0.5213	45.32	4	0.0000
Ba:Ca	1.9758	45.42	4	0.0000
Pb:Ca	0.9784	3.50	4	0.0181

TABLE 5. Results of forward stepwise linear discriminant function analysis for classifying juvenile westslope cutthroat trout to their natal tributary based on the trace element signatures of individual scales. Values indicate predicted classifications with Mg:Ca, Mn:Ca, Sr:Ca, Ba:Ca, and Pb:Ca as dependent variables.

Sample stream	Sample size (n)	Percent Correct	Predicted classifications				
					North Fork		
			Camas	Hay	Langford	Sage	Tuchuck
Camas	28	93	26	0	1	0	1
Hay	28	96	0	27	0	1	0
Langford	27	89	1	0	24	0	2
Sage	14	100	0	0	0	14	0
Tuchuck	29	86	0	0	4	0	25
Total	126	92	27	27	29	15	28
					Middle Fork		
			Bowl	Cox	Morrison	Ole	
Bowl	12	100	12	0	0	0	
Cox	26	96	0	25	1	0	
Morrison	11	100	0	0	11	0	
Ole	7	100	0	0	0	7	
Total	56	98	12	25	12	7	
					South Fork		
			Danaher	Little Salmon	White	Youngs	
Danaher	25	80	20	4	0	1	
Little Salmon	26	73	4	19	0	3	
White	29	72	1	5	21	2	
Youngs	29	86	0	4	0	25	
Total	109	78	25	32	21	31	

TABLE 6. Standardized canonical discriminant function coefficients for trace element ratios of juvenile westslope cutthroat trout scales used to classify fish to their natal tributary in the North Fork, Middle Fork, and South Fork Flathead River drainage in 2001 and 2002.

Canonical Root	Element Ratio				
	Sr:Ca	Ba:Ca	Mn:Ca	Pb:Ca	Mg:Ca
			North Fork		
Root 1	-0.8730	0.0328	-0.2811	0.1324	-0.0390
Root 2	0.2524	0.7187	-0.3422	-0.0935	-0.0784
			Middle Fork		
Root 1	0.9722	0.3906	0.0800	-0.0642	na
Root 2	0.0675	-0.6968	0.3673	-0.1484	na
			South Fork		
Root 1	-0.8384	-0.4526	-0.8029	0.0767	na
Root 2	-0.0447	0.8385	0.1476	0.1823	na
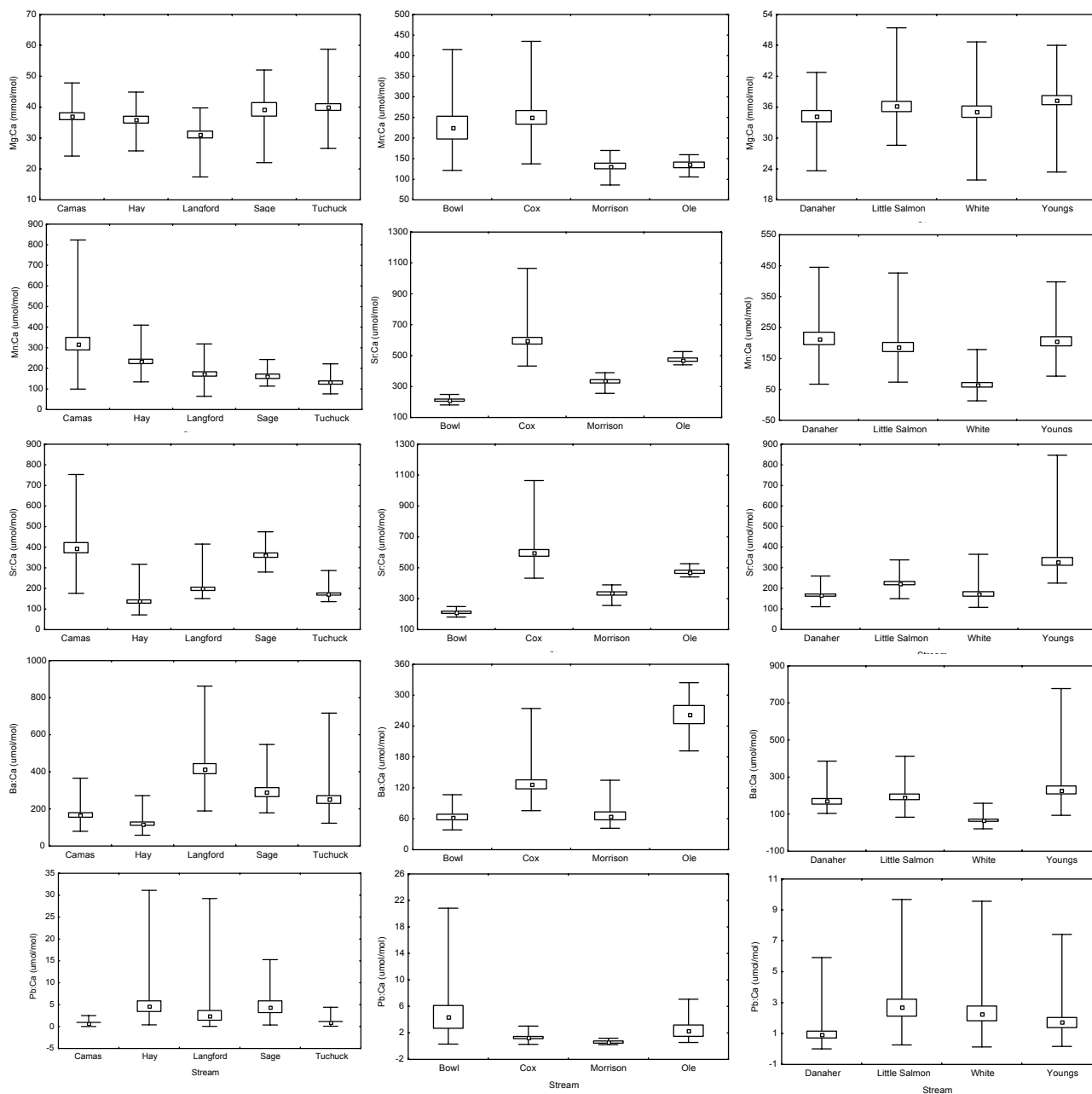
FIGURE 2. Mean concentrations of five element:Ca ratios for streams in the North Fork, Middle Fork, and South Fork Flathead River drainage in 2001 and 2002. Small boxes indicate mean values, large boxes the standard error (SE), and whiskers the minimum and maximum values.

FIGURE 3. Plots of the first and second canonical variates to portray differences in scale elemental signatures from Juvenile westslop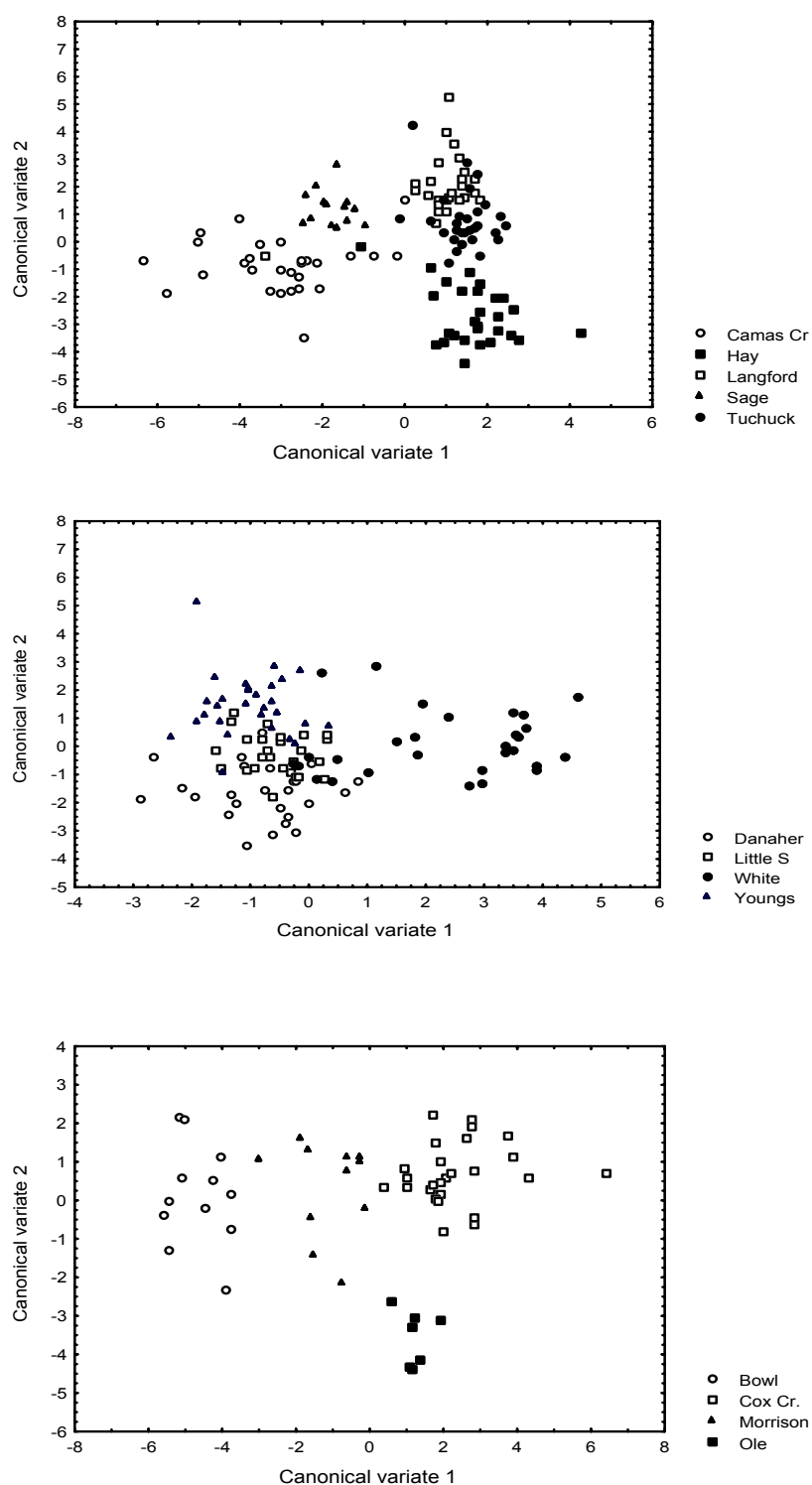e cutthroat trout in streams of the North Fork, Middle Fork, and South Fork Flathead River drainages, Montana. Variables used in the canonical analysis are Mg:Ca, Mn:Ca, Sr:Ca, Ba:Ca, and Pb:Ca.

Aquatic Nuisance Species Project

The threat of Zebra Mussels and other Aquatic Nuisance Species (ANS) pose an immense threat to aquatic ecosystems throughout the United States. Preventing or delaying the spread and establishment of ANS will help protect and conserve important aquatic organisms and will help save millions of dollars spent annually for the restoration of infested areas.

Anglers traveling westward from ANS- infested areas for sportfishing and recreational fishing purposes can spread ANS. For example, participants in bass and walleye tournaments often travel between zebra mussel- infested waters (e.g., Great Lakes) into uninfected waters (e.g., Washington, Oregon, Idaho, Montana, and Wyoming). Therefore, Montana Fish, Wildlife & Parks, the Pacific States Marine Fisheries Commission, and the U.S. Fish and Wildlife Service initiated a cooperative effort to install three Traveler Information Systems (TIS) in Montana to help prevent the westward spread of zebra mussels and other ANS related species into Montana.

Project Progress

The establishment of ANS poses a severe threat to the integrity of aquatic ecosystems in Montana and elsewhere in the United States. Resource managers are concerned about the spread of ANS throughout the western United States primarily because ANS can be easily transported and spread into uninfested waterbodies. For example, recreational boats serve as a likely vector for spreading Zebra mussels (*Dreissena polymorha*), Eurasian watermillfoil (*Myriophyllum spicatum*), and New Zealand mud snails (*Potamopyrgus antipodarum*) from infested to uninfested waters.

Montana Fish, Wildlife & Parks is in the process of installing three Traveler Information Stations (TIS; low frequency radio) throughout Montana (Figure 1). Each station will have signs posted along the highway that alert travelers to tune into a specific radio station that will have an ANS related message. Each TIS system message will target recreational anglers and boaters and will contain educational and preventative information on the spread and prevention of ANS.

FIGURE 1. Example of a Traveler Information System (TIS) in Montana.

The locations and status of the TIS systems in Montana are as follows (Figure 2):

1. Southwestern Montana- Gallatin County, Madison River, Montana

    -   An electrician has been contracted and site location has been confirmed for the radio station power supply, pole installation, and highway sign location.
    -   The power supply and radio station equipment will be housed at a Montana Fish, Wildlife & Parks (MFWP) wardens residence.
    -   The location is 400 hundred yards east of Highway 191 adjacent to the Madison River in Gallatin County. Signs will also be located in this area.
    -   This area of the Madison has an infestation of New Zealand Mud Snails and is used extensively by anglers in this area. The threat also exists for anglers and aquatic recreationists traveling from Yellowstone National Park transporting New Zealand Mud Snails to other bodies of water outside the park.

2. Eastern Montana location Highway 2, Culbertson,Montana

    -   Located at the Montana Department of Transportation (MDOT) Weigh Station.
    -   Verbal approval has been awarded by MDOT (Helena) for the installation and operation at this site. Currently, MFWP and MDOT are working on a Memorandum of Understanding (MOU) with for the installation of this system.

3. Eastern Montana, I94, Wibaux, Montana

    -   Located at the Montana Department of Transportation (MDOT) Weigh Station.
    -   Verbal approval has been awarded by MDOT (Helena) for the installation and operation at this site. Currently, MFWP and MDOT are working on a Memorandum of Understanding (MOU) with for the installation of this system.
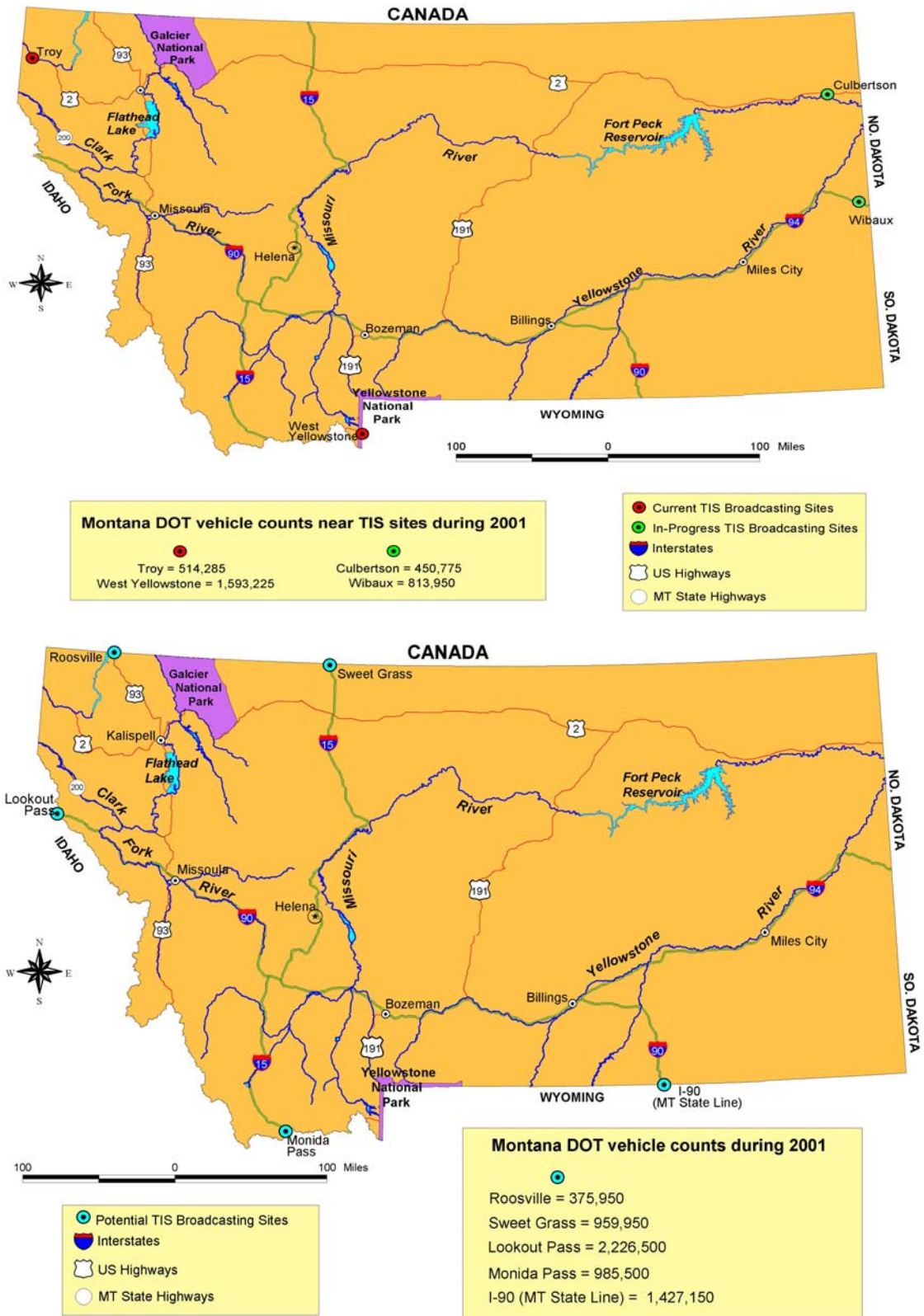
FIGURE 2. Current and proposed locations of Traveler Information Systems (TIS) in Montana.

Signs

To help prevent a mixed message being sent to travelers into Montana and to stay consistent with the U.S. Fish & Wildlife Service "Stop Aquatic Hitchhikers" Program, signs that will be installed for all three (TIS) Systems will read as follows:

<div align="center">

STOP AQUATIC HITCHIKERS!
ANGLERS & BOATERS
TUNE RADIO TO AM   XXXX кHz

</div>

Note: Signs will meet the (MDOT) standards for highway speeds, colors, and size.

Other ANS related projects:

Other projects that have been carried out through the course of the 2002 calendar year have been:

- Radio Public Service Announcement (PSA) in the Kalispell area and also in the Polson area. MFWP and the Salish & Kootenai tribe cost –shared this project. Also worked with Flathead Salish & Kootenai tribal fisheries biologist with signs and brochures regarding ANS information and education for tribal lands.
- Worked with Tri- State Water Quality Council, Sandpoint, ID. And Avista Corp. to cost share a TIS system on Highway 200 coming into Montana from Idaho. Work is still in progress.
- ANS message regarding cleaning boats and equipment inserted in MFWP 2002-2004 Fishing Regulations
- Pursuing an ANS hot link to MFWP web page.
- Providing information regarding ANS species to a MFWP Lewis & Clark Bicentennial web site. The information will provide readers with boat and equipment cleaning information regarding Zebra Mussels as well as an explanation of what a Zebra Mussel looks like. Also a Bonneville Power Administration (BPA) 800 number to report any Zebra Mussel sightings on boats or trailers that might be on Montana's roadways or about to enter any waterbodies.
- Montana's Aquatic Nuisance Species Management Plan was completed September 2002. Aquatic Species Task Force has approved the plan. This will entitle Montana for funding to implement the plans components.
- Working with the Columbia River Basin ANS work group. Group discusses ongoing projects regarding ANS in the Columbia River basin.
- Working with the 100th Meridian Initiative to prevent the further spread of zebra mussels. The 100th Meridian Initiative is a comprehensive prevention partnership that includes State and Federal agencies, private industries, and user groups. Among other components of the Initiative, voluntary boat checks are available in the six States and Manitoba that straddle the 100th Meridian (100° longitude.)

Sekokini Springs Natural Rearing Facility

The goal of the Hungry Horse Mitigation Program is to mitigate fisheries losses attributable to the construction and operation of Hungry Horse Dam. Council approved fisheries losses include 65,500 juvenile westslope cutthroat trout annually, to be restored using a combination of habitat restoration, dam operation changes and experimental hatchery techniques. The Sekokini Springs site will be used in the restoration of westslope cutthroat in the Flathead Drainage by preserving and replicating pure genetic stocks. Wild juveniles from endemic donor populations will be raised in restored natural habitat at the site to preserve behavioral traits and provide gametes for reestablishing F1 progeny in selected areas where the species has been extirpated. The site will also conserve remnant populations that are threatened by nonnative species or environmental damage. Rescued fish will be protected at the site and raised to create a donor population for reintroduction to their aboriginal habitat after the threats are eliminated.

Nonnative species or environmental damage in some locations threatens remnant populations of genetically pure cutthroat and there is a need to conserve the genetic diversity of the species. Genetic inventories of existing stocks of westslope cutthroat trout have revealed that hybridized/introgressed populations in headwater lakes are threatening pure populations downstream. Lake rehabilitation has been initiated to remove this threat to pure native stocks. A source of genetically compatible fish is needed to replace these populations. The hatchery portion of the Hungry Horse Mitigation program is presently in transition to experimental culture of native species as directed by the Hungry Horse Mitigation Plan (MFWP and CSKT 1991) and Implementation Plan (1993). The Northwest Power Planning Council (NPPC) approved the plans and amended their Columbia Basin Fish and Wildlife Program (Measure 10.3A, NPPC 1995).

In 2002 FishPro Consultants of Port Orchard, Washington where contracted to complete the necessary components for future funding of the completion this facility. Bonneville Power Administration (BPA) felt that FishPro's extensive experience of the Northwest Power Planning Councils (NWPPC) 3 Step process would be beneficial to the proper completion of this document. The Master Plan will be restructured by FishPro to put it in a familiar form that (NWPPC) is accustomed to. FishPro also completed additional surveying to estimate fill requirements for the stream course, holding ponds, and interpretive pathways that are to be constructed in the future.

The current work will complete step 1 of the 3-step process. Step 2 of the 3-step process will require National Environmental Policy Act (NEPA) documentation. The (BPA) will take the lead in implementing the proper procedures. Step 3 is the final design and FishPro is currently working on that simultaneously with the step 1 document. The Bureau of Reclamation (BOR) Technical Assistance program engineers are currently working on detailed engineered designs of the rearing pond facilities.

Projects that where completed this year consisted of new aluminum siding being replaced on the entire structure of the rearing facility. Also the interior of the facility was insulated with 5 inches of foam insulation in the ceilings and 3 inches of foam in the walls. Upon completion of the insulation work the walls where covered with a fireproof coating.

A Bioenergetics Approach to Investigate the Interactions between Non-native Northern Pike and Native Salmonids in the Lower Flathead River

Northern pike *Esox lucius* were illegally introduced and have become self-sustaining in the lower Flathead River above Flathead Lake, Montana. In 1953, northern pike were illegally planted into Lone Pine Reservoir (near Hot Springs, Montana) from Lake Sherburne, Glacier National Park (MDFWP, unpublished data, Kalispell, Montana). In the early 1970's, northern pike were illegally introduced to the upper Flathead River drainage (upstream of Flathead Lake) and became a popular sport fishery beginning in the 1980's. Northern pike abundance probably peaked in the 1980's, a time of peak bull trout abundance. The current distribution of northern pike in the upper Flathead River system includes Flathead Lake, the Flathead River downstream of the Stillwater River, and the Stillwater, Whitefish and Swan River drainages.

The Flathead River drainage harbors migratory populations of native bull trout and westslope cutthroat trout. Currently, bull trout are listed as a threatened species under the Endangered Species Act (ESA) and westslope cutthroat trout are recognized as a species of special concern by the American Fisheries Society and Montana Fish, Wildlife & Parks. Due to apparent declines in native trout populations, concerns have arisen that the pike may be adversely impacting native trout populations (Muhlfeld et al. 2001 and 2002). Increasing local popularity of the northern pike fishery and the potential adverse effects on native species has prompted fisheries managers to collect baseline ecological information (i.e. movements, abundance, size-class structure, food habits etc.) on the northern pike population in the upper Flathead River system.

The 2002 project objectives are:

1. To estimate the abundance of piscivorous size-classes of northern pike; and

2. To describe the seasonal distribution of pike, and relate movements to temperature, flow and lake elevation.

Study area

The study area includes the lower section of the Flathead River (above Kerr Dam) that begins at the confluence of the Stillwater River and mainstem Flathead River and flows in a southerly direction for 32 km before entering the north end of Flathead Lake, Flathead County, Montana. The lower Flathead River is a low-gradient (< 0.4 m/km) sinuous channel dominated by deep run habitat in the main channel with connected slough habitats present in lateral areas of the floodplain. This reach is characterized by

sand, silt and gravel substrates and dominated by rooted and floating aquatic vegetation in the summer. Maximum recorded depth of the lower Flathead River is 27.5 m. This portion of the river is influenced by seasonal backwater affects (vertical fluctuations of approximately 3 m) caused by the impoundment of Flathead Lake by Kerr Dam. Because Flathead Lake is held near full pool for water storage from June through September, water levels in the lower portion of the Flathead River increase during summer transforming the lower river from a lotic to a lentic dominated aquatic environment. When Flathead Lake is at full pool, approximately 35 km of the Flathead River becomes a backwater. The mainstem Flathead River is regulated by water releases from Hungry Horse Dam downstream of the confluence with the South Fork Flathead River. Dam operations have essentially reversed the natural hydrograph resulting in the storage of spring melt during spring and summer and releasing water in the fall and winter when flows were historically low.

Methods

Objective 1: Estimate the abundance of piscivorous size-classes of northern pike.

Field crews deployed fyke nets throughout sloughs and in the lower river above Flathead Lake beginning in April 2002. The average number of nets deployed was 12 per day and ranged from 9-13 per day due to net repairs and maintenance. Trapping occurred in the spring (April-June) during runoff and continued throughout late summer and fall 2002 and will resume in late winter and early spring 2003. Ice formation in sloughs and river precluded sampling during winter. Custom fyke nets were made with two rectangular frames at the mouth to prevent the net from rolling on the bottom. The frames were made of metal conduit tubing, measuring 1.2 x 1.8 m. Following these rectangular frames are three fiberglass hoop frames with a 1.2 m diameter, which funnels into a holding area. A custom-built escape hatch, which opened from holding area was a 2.4 m mesh tube extending to the surface attached to a .6 m pvc frame with floats. This was added later to allow for the passage of otters entering traps. One lead was attached to the center of the trap mouth and extended 60 feet to shore. All mesh was 1" in diameter. Traps were set with the lead anchored with rebar near shoreline extending to center of trap mouth. A jet boat was used to pull traps so leads were stretched perpendicular to the shoreline. Therefore, fish moving in either direction along shoreline intersect lead net and are directed into the holding area.

Traps were fished 24-hours a day 7 days a week. Field crews checked traps everyday or every other day during spawning months and every 2 to 3 days during summer and fall months when traps caught few to no fish. Traps were left unchecked through most weekends. We identified and enumerated each captured fish species and acquired lengths (to the nearest mm) and weights (grams) on all northern pike. Northern pike captured were marked by inserting an external spaghetti tag at the base of the dorsal fin and released near the capture site. Each tag was individually numbered and printed with a return address that included a $5.00 reward statement to increase the probability of tag returns from anglers. A few northern pike captured were not tagged due to size or if

determined unfit to survive. All recaptured northern pike from traps were recorded and released.

Catch per unit effort (CPUE) was calculated as the total number of pike per month captured, divided by the total number of trapping hours per month. Stream temperature and discharge information was obtained from Columbia Falls USGS monitoring site on the Flathead River.

FIGURE 1. Example of a northern pike captured and marked by inserting an external spaghetti tag at the base of the dorsal fin and released near the capture site.

Objective 2: Describe the seasonal distribution of pike, and relate movements to temperature, flow and lake elevation.

We investigated the seasonal movement and distribution of northern pike, and related the timing and duration of movements to water temperature, river discharge and lake elevation. This data will also help inform sampling efforts as described in objectives 2-4 (see below). Sixteen adult pike were captured in the river and connected sloughs during April 2002 and surgically implanted with radio-transmitters. Fish were relocated at least 3 times per week using a jet boat equipped with a Lotek W30 receiver and a directional whip antenna. Fish locations were recorded with a GPS unit ($\pm$ 1 m accuracy). Habitat use was characterized at each location as slough or river. Water depth was measured at each location using a depth meter. Cover (within a 10 m radius of each location) was classified as rooted aquatic vegetation, woody debris, and overhanging vegetation. Continuously recording temperature monitors (Hobo) were deployed in Fennon, Church, Halfmoon, and Rose Creek sloughs (2 per slough), and at two locations throughout the lower river throughout the study period. Discharge information will be obtained from the Columbia Falls USGS flow monitoring site on the Flathead River.

Results

Objective 1

The abundance of northern pike will be estimated using a multiple mark-recapture approach. The following is a summary of the 2002 preliminary results of this ongoing project:

- Fyke traps were deployed in Halfmoon, Church, Fennon, Rose Creek, Egan outlet, and Mill Creek sloughs for a total of 35,679 trapping hours, and in the river for a total of 12,646 trapping hours (Table 1).

- We captured a total of 367 pike during 2002. Of the 367 pike, 316 were captured in the sloughs and 51 were captured in the main river (Table 1). Seventy-two of the captured pike were not tagged due to size, condition factor, or because the individual was recaptured.

- Captured pike ranged from 200 mm to 1045 mm in length (TL), with a majority of the fish greater than 400 mm (Figure 1). Mean lengths of the captured pike were higher in the spring and declined in the summer and fall.

- The number of pike captured in fyke traps declined from spring to fall (Table 1; Figure 2). The number of captured pike was greatest in April (n = 143; 39% of total capture), May (n = 55; 15 % of total capture), and June (n = 75; 20% of total capture), and declined during summer and fall (26%). Monthly CPUE values for northern pike followed similar trends as observed in the total catch information (Table 1). Muhlfeld et al. (1999), studying the seasonal composition of fishes inhabiting the upper Flathead River sloughs, Montana, reported similar findings.

TABLE 1. Monthly catch information for northern pike in the Flathead River sloughs and main-stem during 2002.

| Sample month	Total trap hours	Number of captured pike	Number of pike tagged	Number of recaptured pike	Pike not tagged	Mean TL (mm)	Pike CPUE
			Slough Catch				
April	4222	121	114	3	4	645	0.029
May	6294	55	43	8	4	613	0.009
Jun	7265	75	51	23	1	615	0.010
Jul	7662	31	21	10	0	606	0.004
Aug	4587	24	18	3	3	555	0.005
Sep	1412	8	2	0	6	309	0.006
Oct	4237	2	2	0	0	339	0.000
Total	35679	316	251	47	18		
			River catch				
April	1729	22	22	0	0	667	0.013
May	0	0	0	0	0	na	na
Jun	0	0	0	0	0	na	na
Jul	577	2	2	0	0	549	0.003
Aug	3630	8	7	0	1	579	0.002
Sep	3160	8	3	0	5	424	0.003
Oct	3550	11	10	0	1	351	0.003
Totals	12646	51	44	0	7		
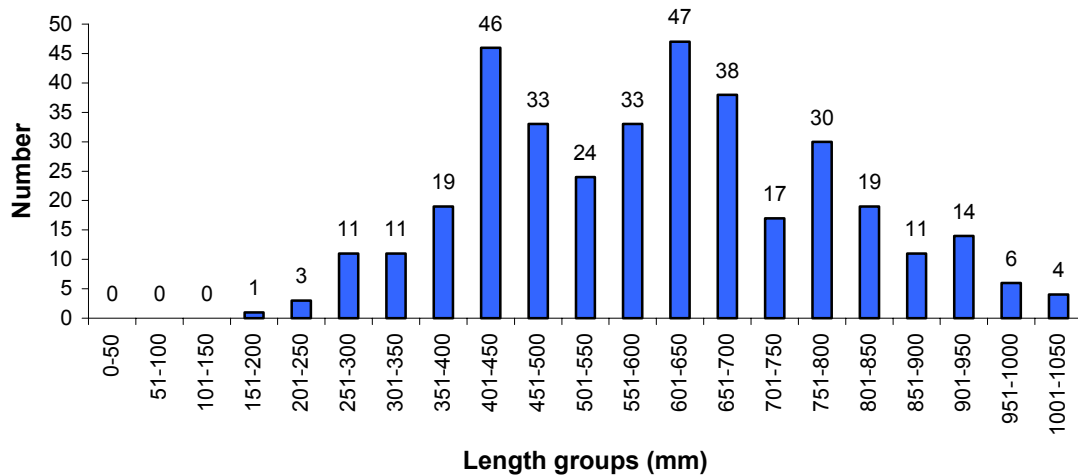
Figure 1. Length frequency of northern pike (n = 367) captured in fyke traps in the Flathead River and sloughs in 2002.
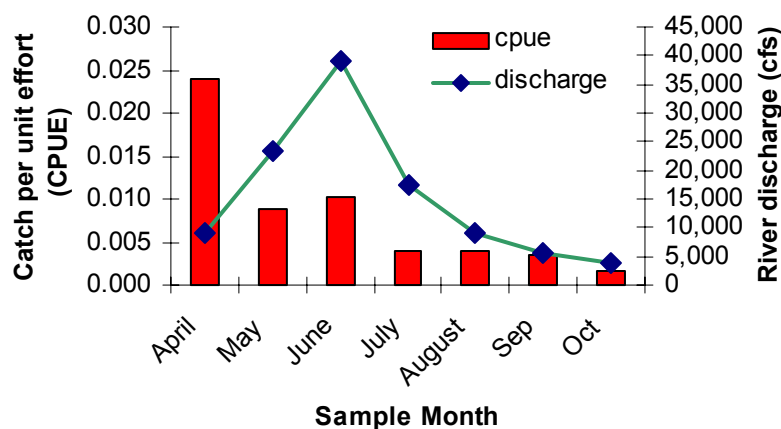
FIGURE 2. Catch per unit effort (CPUE) for northern pike captured in fyke traps as related to river discharge in the upper Flathead River sloughs and main-stem in 2002.

Objective 2

The 16 northern pike (mean total length = 739 mm; range: 560-955 mm) monitored in 2002 were successfully radio-tracked for an average of 263 d (range: 49-553 d) and relocated an average of 29 times (range 6-49) throughout the study period (Table 1; Figure 1). Seven fish were tracked until battery expiration; four fish were found dead, and anglers harvested the remaining five. Examination of fish recaptured in fyke traps showed that shortly after implantation fish displayed normal behavior and appeared to heal quickly from the surgery.

TABLE 1. Radio-tagged northern pike monitored in the upper Flathead River in 2002.

| Tag number	Total length (mm)	Total weight (g)	Number of relocations	Tagging location	Tagging date	Final location date	Number of days tracked	Fate
79	654	2318	5	Ashley Creek mouth	2-Apr	16-Sep	167	harvested
127	635	2360	47	Flathead river	9-Apr	10-Dec	245	harvested
74	630	2005	20	Fennon slough	9-Apr	10-Dec	245	harvested
130	621	2251	45	Fennon slough	9-Apr	12-Dec	247	alive
128	650	2375	23	Fennon slough	9-Apr	10-Dec	245	harvested
129	869	5949	27	Fennon slough	9-Apr	12-Dec	247	alive
118	651	2335	37	Ashley Creek mouth	10-Apr	25-Oct	198	dead
78	800	3905	21	Ashley Creek mouth	10-Apr	12-Mar	336	alive
119	772	4153	47	Fennon slough	11-Apr	4-Dec	237	alive
120	821	4631	49	Fennon slough	11-Apr	12-Dec	610	alive
121	955	7718	13	Flathead river	16-Apr	4-Jun	49	dead
122	928	7491	29	Flathead river	16-Apr	1-Nov	199	alive
123	757	3634	39	Flathead river	16-Apr	21-Oct	553	dead
124	685	2909	32	Flathead river	16-Apr	25-Oct	192	dead
125	560	1383	25	Church slough	24-Apr	4-Aug	102	harvested
125	828	4821	6	Flathead river	17-Apr	12-Mar	329	alive

$y = 15.866x - 7952.2$
$R^2 = 0.9569$
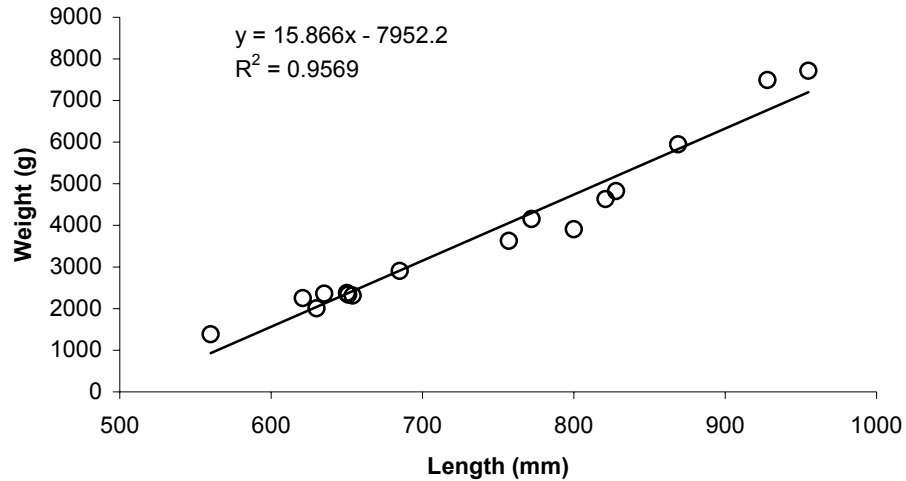
FIGURE 1. Length-weight relationship of the 16 radio-tagged northern pike.

Our movement results suggest that the Flathead River population of northern pike consists of two components, one that occupies restricted home ranges and another that moves extensively throughout the river-lake system. Sedentary fish commonly occupied the same slough where they were originally captured and released, whereas migratory northern pike moved throughout the river and connected sloughs. Population density is likely the key factor determining the number of transients and residents present in a population (Chapman and Bjornn 1969).

Our results suggest that northern pike occupied defined home ranges in the lower Flathead River within areas of contiguous suitable habitat. Diana et al. (1977), Chapman and Mackay (1984) and Cook and Bergerson (1988) reported that northern pike did not occupy defined home ranges throughout the particular lake or reservoir possibly because these systems were relatively small and shallow or due to short tracking periods. Conversely, Rich (1992) found that home ranges occupied by northern pike were positively related to the area of continuous suitable habitat in a given area in Coeur d' Alene Lake, Idaho. In the Flathead system, suitable pike habitat is probably limited to sloughs and deep, slow-moving areas of the lower Flathead River and Flathead Lake.

Northern pike were consistently relocated in backwater areas of the Flathead River sloughs during spring, which coincided with rising water temperatures and increased river discharge. Northern pike spawn during April and May during the daylight hours and prefer submerged vegetation in floodplains of rivers, marshes and bays of lakes (Scott and Crossman 1973). Therefore, Flathead River sloughs probably contain suitable spawning and rearing habitat for northern pike due to their shallow and well-vegetated characteristics. However, because Flathead Lake reaches full pool in June, Flathead River pike may have to wait until late May or early June to find suitable spawning substrate in the lateral areas of the river sloughs that is otherwise inaccessible at lower lake elevations.

Our results suggest that slough habitat was used more than expected by northern pike in the Flathead River system above Flathead Lake. Sedentary fish were consistently relocated in the same slough where they were originally captured and released in or displayed movements to other sloughs during their respective monitoring periods. Furthermore, mobile northern pike frequently moved between sloughs and the main river. In the Flathead River, slough habitat likely provides northern pike with abundant prey and contain relatively warm, slow moving water with abundant aquatic vegetation. Cook and Bergersen (1988) found that northern pike preferred vegetated littoral areas and would adjust their locations in response to changes in macrophyte density and distribution in Eleven Mile Reservoir, Colorado. Diana et al. (1977) also found that pike were frequently located in vegetated, near shore areas in Lac Ste. Anne, Alberta.

Radio-tagged northern pike were not found in the Flathead River upstream of the confluence of the Stillwater River throughout the study period. We believe that the upper portion of the river is probably unsuitable for northern pike because the river transforms from a lentic to a lotic dominated river environment.

Some radio-tagged northern pike displayed frequent long-distance (up to 25 km) movements throughout the lower river and associated sloughs during summer. The lower portion of the Flathead is influenced by seasonal backwater affects (vertical fluctuations of approximately 3 m) caused by the impoundment of Flathead Lake at Kerr Dam. Flathead Lake is held near full pool for water storage from June through September. Thus, water levels in the river rise creating a slow-moving lentic environment. We believe that increasing water levels caused by Kerr Dam probably promotes suitable habitat conditions (i.e. slow-moving water) for northern pike and permits access to river sloughs in the lower Flathead River.

Future Investigations

The following objective will also be addressed in 2003:

Objective 3: Quantify the predatory effects of northern pike on juvenile bull trout and westslope cutthroat trout

Food habits.— To quantify the relative consumption of bull trout and westslope cutthroat trout by northern pike, stomach samples will be collected from northern pike by angling (volunteer anglers), netting, and boat electrofishing (at night). Samples will be collected throughout the study period to assess seasonal variability in the diets of northern pike. Stomachs will be collected from harvested fish by removing the entire stomach from the body. Further, stomach samples will be potentially collected from live fish using lavage techniques (Light et al. 1983); however, lavage techniques may not be effective due to the elongated guts of northern pike (Vidergar 2000). Samples will be preserved in 10% formalin and labeled with species, location of catch, length of predator, and date. Fish prey items will be identified from stomachs to the lowest practical

taxonomic level, enumerated, and weighed by trained technicians at the University of Idaho.

Predatory impact.— The total annual consumption of bull trout and westslope cutthroat trout will be estimated using the computer model Fish Bioenergetics 3.0 (Hanson et al. 1997). Consumption estimates will be obtained from the food habits data, and consumption will be estimated by fitting a known growth curve. Parameters used in the model will include: estimates of northern pike size-classes, mortality estimates (from growth curves), and weight at age estimates, temperature availability, and dietary composition. Dr. David H. Bennett (University of Idaho) will assist the project biologist with model development.

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